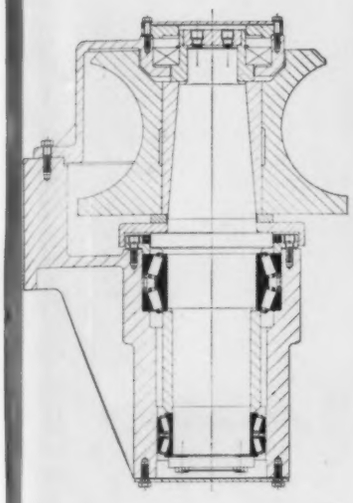
Iron AND Steel ENGINEER

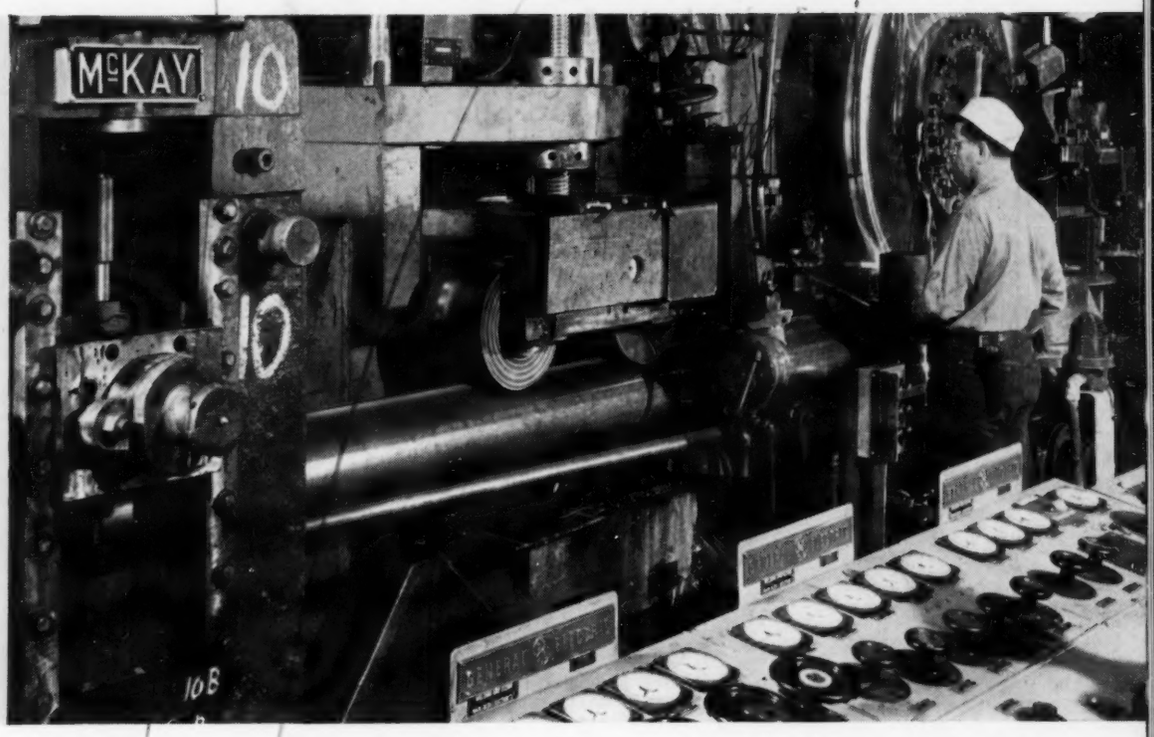
ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

TECHNOLOGY DEPT.

MARCH, 1959



How **McKAY** mounts Pipe Mill pressure roll to take heavy loads and reduce maintenance.



Timken® bearings take heavy loads on McKay 12¾" pipe mill at J & L

ROLLING out 120 feet-a-minute of 12¾" OD electriweld pipe, an advanced design McKay Pipe Mill is setting new production records at Jones & Laughlin, Aliquippa, Pennsylvania.

To get this, engineers mounted five Timken® tapered roller bearings on the pressure roll shafts and at other vital points. They take the heavy shock loads as pressure rolls upset the pipe edges during the welding operation. These same bearings must take the terrific sizing loads which are present when any cold pipe comes through the welding pass.

Timken bearings' rollers and races are case-carburized to produce hard, wear-resistant surfaces over tough, shock-resistant cores that add longer life to bearings and machine, smooth the way for minimum down time and record production.

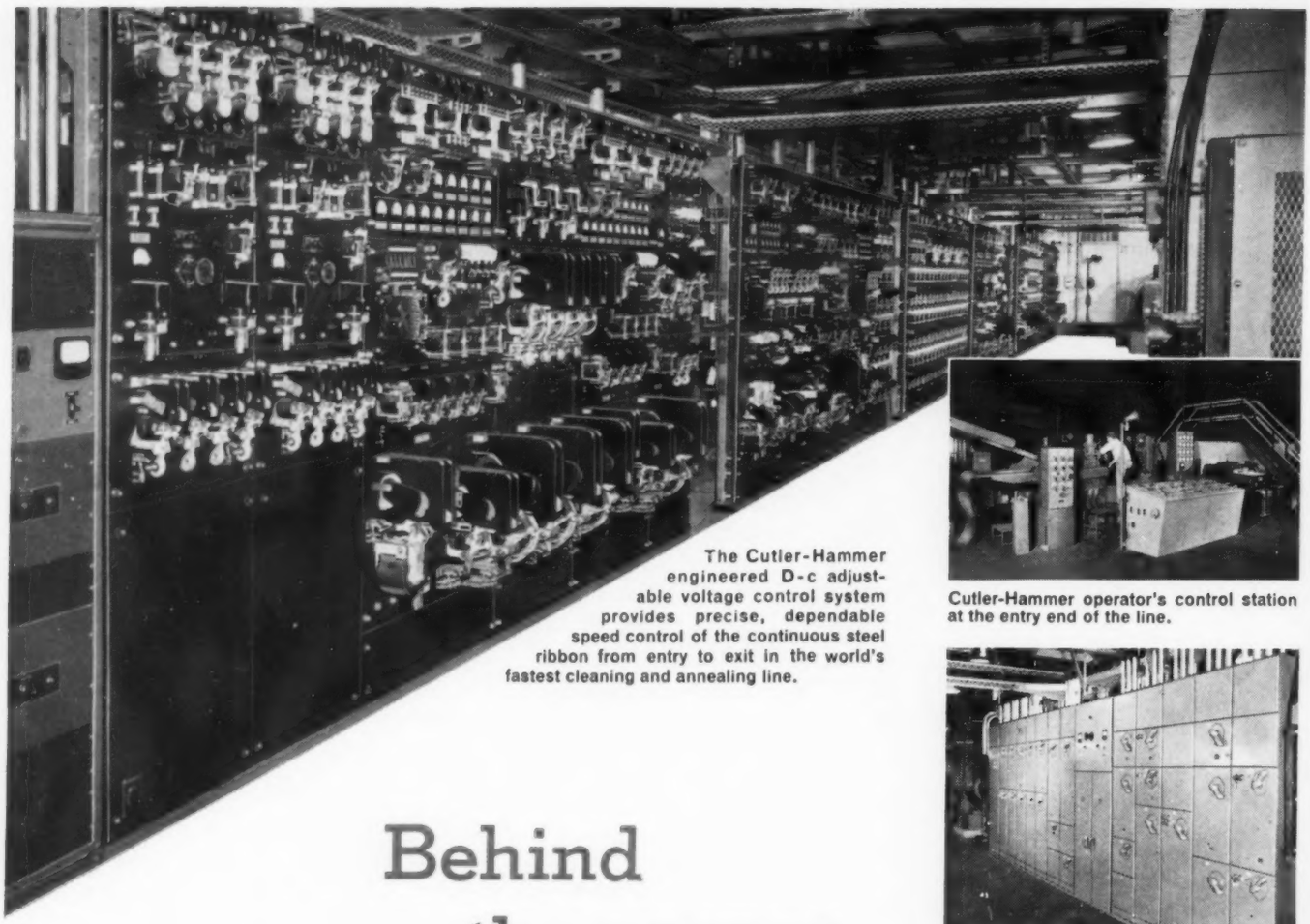
The smoke and spatter of welding operations make tight closures a *must.* Timken bearings hold shafts concentric with their housings, making closures more effective in keeping dust and dirt out, lubricant in. Maintenance, of course, stays *down.*

Timken bearings take all the stresses in stride because they take both radial and thrust loads, or any combination of loads. They roll the load. Friction is virtually eliminated because Timken bearings are designed by geometric law to have true rolling motion. And they're precision manufactured to live up to their design.

Timken bearings help put go and life in your machines—to make better products, make bigger profits. That's BETTER-ness. Specify Timken bearings. They're at the hub of BETTER-ness. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.

BETTER-ness rolls on **TIMKEN®** tapered roller bearings

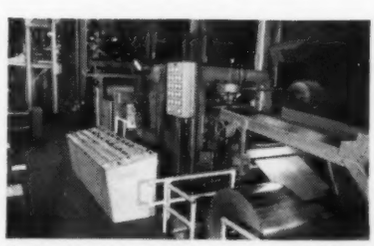


The Cutler-Hammer engineered D-c adjustable voltage control system provides precise, dependable speed control of the continuous steel ribbon from entry to exit in the world's fastest cleaning and annealing line.

Cutler-Hammer operator's control station at the entry end of the line.

Cutler-Hammer Unitrol provides a convenient, space-saving unit for all A-c auxiliary controls.

Cutler-Hammer 505 Mill Brakes are used on the winding reels and bridle stands.



Cutler-Hammer operator's control station at the exit end of the line.

Behind the scenes at Weirton Steel...

Cutler-Hammer Control keeps the world's fastest continuous cleaning and annealing line on the go

The new continuous strip steel cleaning and annealing line at the Weirton Steel Company division of National Steel Corporation is truly a remarkable engineering achievement. It automatically cleans and anneals an endless ribbon of cold rolled steel at speeds up to 2,000 feet per minute . . . a new world's record. But of equal importance is the fact it can deliver 20,000 tons of steel ready for tin plating every month.

Unquestionably, a processing line such as this represents a major capital investment which must pay for itself through high speed, dependable production day after day . . . month after month . . . year after year. And to a great extent its successful operation depends upon the trouble-free performance of the control equipment which integrates and regulates the complex system of individual machines that go to make up the line.

Here Cutler-Hammer's 65 years of control engineering experience provided the expert "know-how" in designing the *right* control system, the *dependable* control system for this performance champion.

You too will find it pays to work with Cutler-Hammer for the practical solution to all your mill control problems. Your inquiry will receive prompt attention. Write Department E-232, Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

CUTLER·HAMMER
CONTROL
C·H

LOOK TO CUTLER-HAMMER MILL EXPERIENCE...AS BROAD AS IT IS LONG

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

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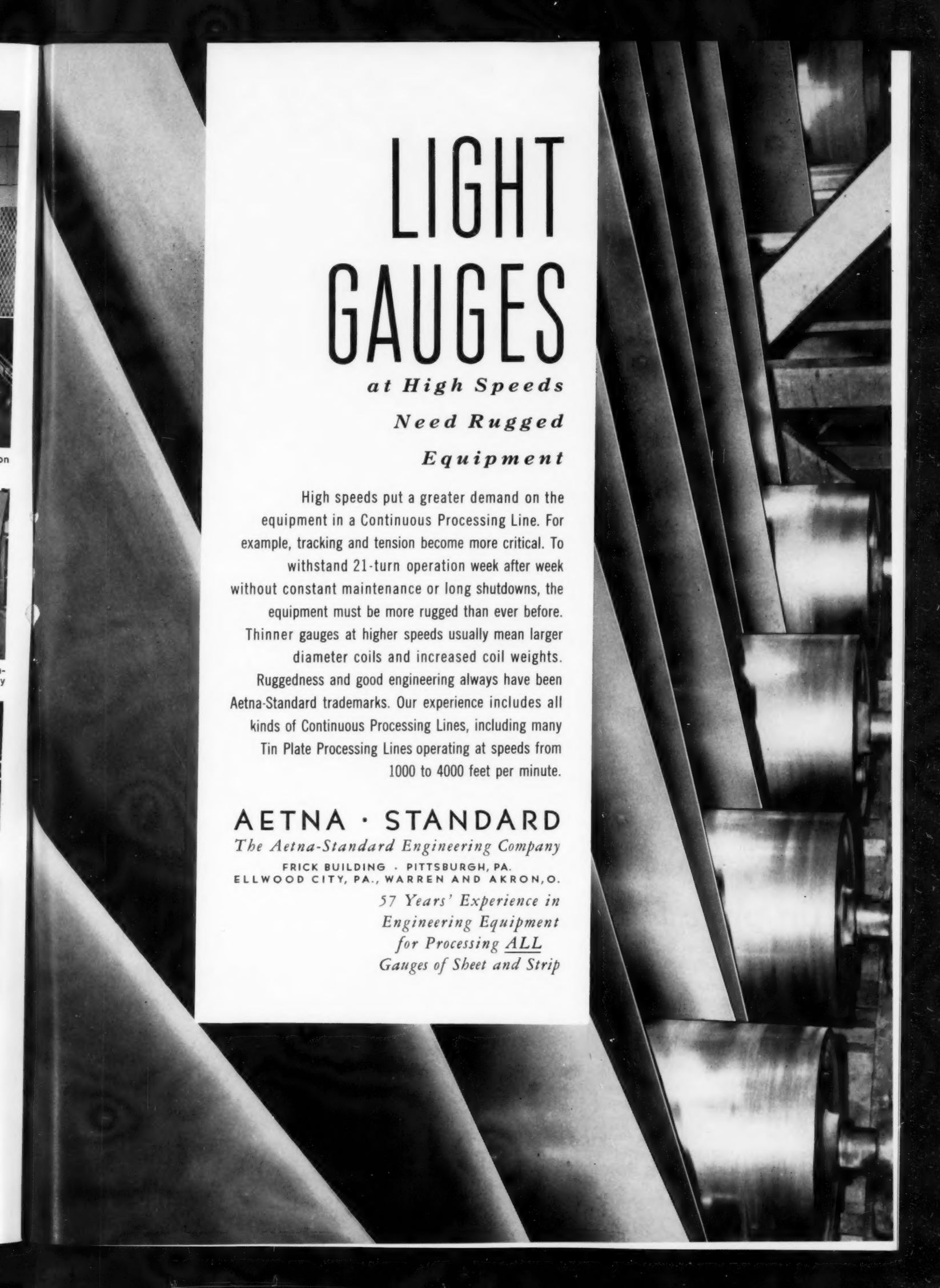

LIGHT GAUGES

at High Speeds

Need Rugged

Equipment

High speeds put a greater demand on the equipment in a Continuous Processing Line. For example, tracking and tension become more critical. To withstand 21-turn operation week after week without constant maintenance or long shutdowns, the equipment must be more rugged than ever before. Thinner gauges at higher speeds usually mean larger diameter coils and increased coil weights. Ruggedness and good engineering always have been Aetna-Standard trademarks. Our experience includes all kinds of Continuous Processing Lines, including many Tin Plate Processing Lines operating at speeds from 1000 to 4000 feet per minute.

AETNA · STANDARD

The Aetna-Standard Engineering Company

FRICK BUILDING · PITTSBURGH, PA.
ELLWOOD CITY, PA., WARREN AND AKRON, O.

57 Years' Experience in Engineering Equipment for Processing ALL Gauges of Sheet and Strip

Eleven Wean lines produce cut-to-length tin plate for Weirton Steel

The eleven Wean shearing lines illustrated process all the cut-to-length tin plate output at the Weirton plant of Weirton Steel Company, Division of National Steel Corporation. The lines incorporate the functions of side trimming, edge conditioning and inspection, as well as shearing to close tolerances at high speeds.

Wean has had extensive experience in the continuous processing of tin plate from cleaning, through annealing and electrolytic tinning to inspection and cut-up. Most of the industry's tin plate facilities have been designed and built by Wean.

Wean's leadership in this field is the result of its close working relationship with the steel industry. Throughout this partnership, Wean's *creative engineering* has helped translate laboratory developments in continuous steel processing techniques into full-scale production installations.

WEAN

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Helping the steel industry grow

The tools of the designer and the engineer, the blueprints which translate their ideas into great steel mills, the raw materials and finished steel—these are the elements of this painting in which Stanley Meltzoff dramatizes America's ever-growing steel industry.

The Economy of Experience

Operating within established budget limits in the design and construction of a steel mill, large or small, calls for experience of the highest order. Only this can effect cost and time-saving advantages—and still assure the smooth teamwork needed in design, purchasing, expediting and construction.

Making experience pay dividends to the client has been demonstrated in the design and installation of such facilities as rolling mills, slab heating furnaces, sintering strands, desulfurizer stations, oxygen plants, power plants, and coal handling equipment.

Let our skills and creativity augment the engineering facilities of your organization. Put to your service the advantages offered by United Engineers, with its background of 75 years' experience.

UNITED ENGINEERS

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You can HOLD THE LOAD while you change coils on CLARK DC BRAKES

On the new improved line of Clark AISE-NEMA DC Magnetic Brakes, you can remove and replace the magnet case and coil as a unit, without releasing shoe pressure or disturbing any brake adjustment. ***Full torque remains applied to the wheel at all times.*** This exclusive feature is particularly important for added safety and convenience on crane applications, especially when loads are being carefully spotted or are suspended over areas where lowering is impractical or impossible.

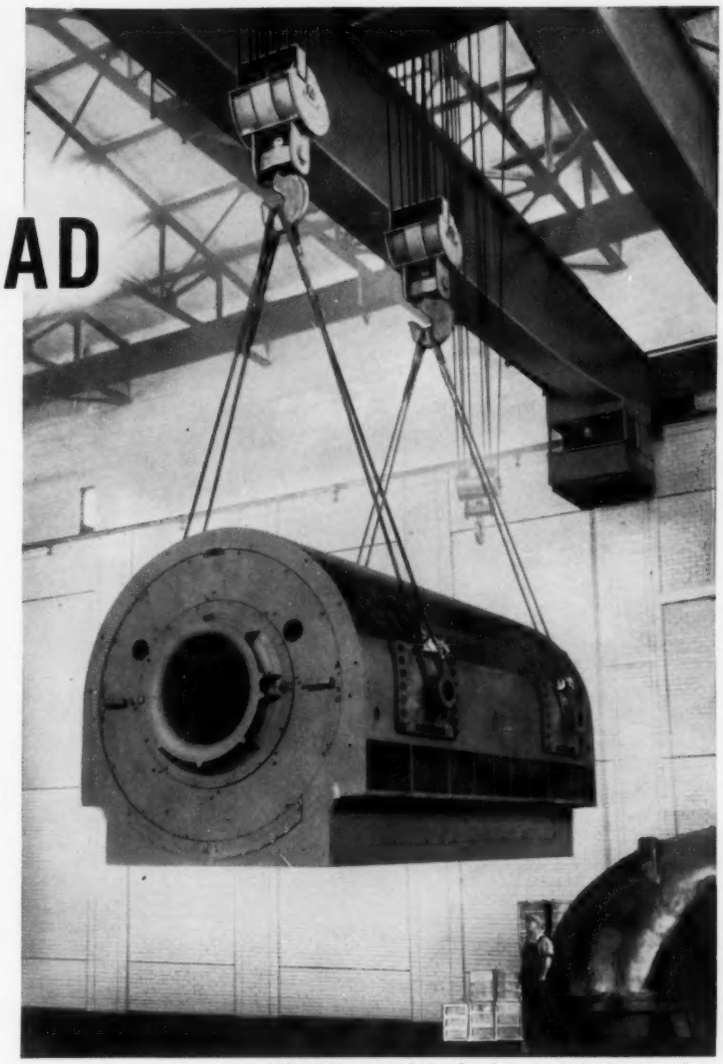
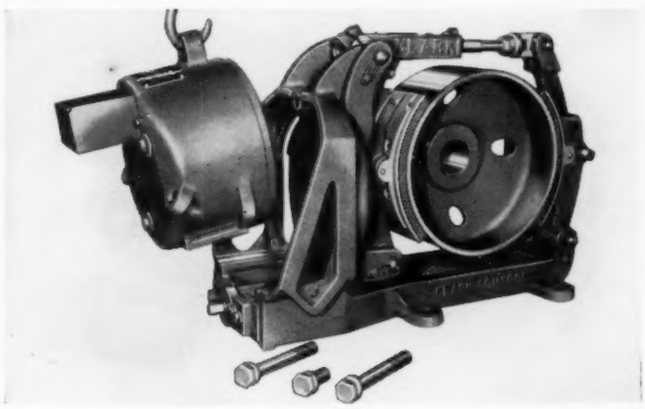
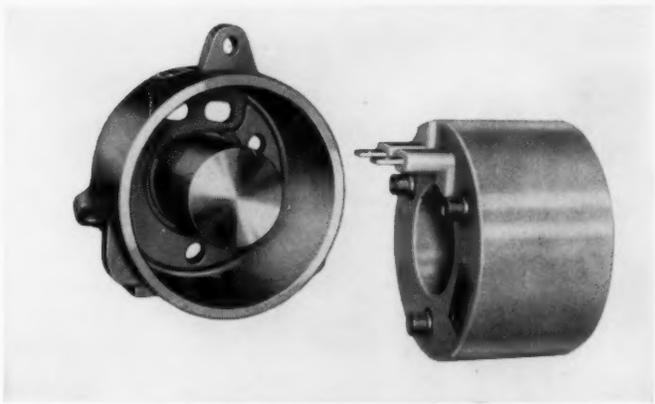


Photo Courtesy of Cleveland Crane & Engineering Co.



By removing 3 bolts, magnet case and coil can be removed on the job without disturbing any other part of the brake. Full torque is maintained.



Epoxy-encapsulated coil is easily removed from magnet case by loosening 3 retainer bolts (4 on larger sizes) allowing coil to slide out.

Clark AISE-NEMA Brakes are now available in 5 sizes, from 10" to 23". For complete information, write for Bulletin 106-B.

The **CLARK CONTROLLER** *Company*

Everything Under Control

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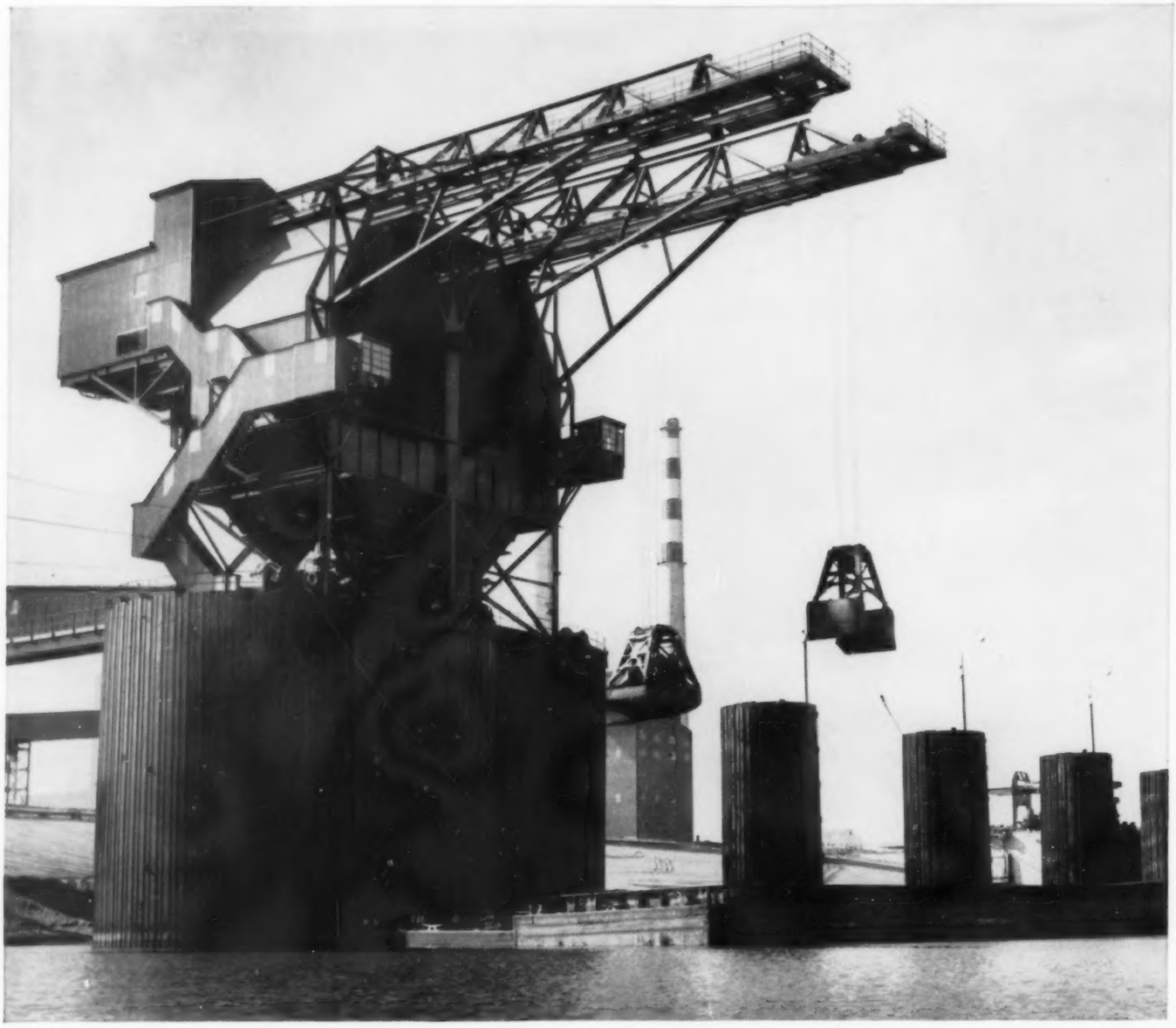
IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO



Dravo builds world's largest coal unloading tower at Memphis

New "Siamese twin" unloader serves 812,500-kw power plant

The world's largest coal unloading tower, designed and built by Dravo, is now serving the new 812,500-kw capacity Thos. H. Allen Generating Station at Memphis, Tenn.

This is the largest steam power plant ever authorized at one time by any municipality and was designed by Burns and Roe, Inc., of New York City, who also supervised plant construction.

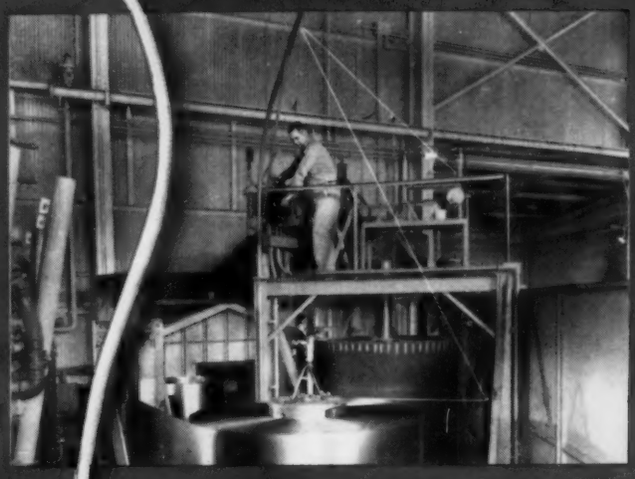
Dubbed "the Siamese twins," the new unloader consists of two towers on a single base. Each of the two unloading units operates a 13.3-ton capacity bucket, with individual adjustable voltage control.

This unloader has a digging capacity of 2600 tons of coal an hour — 1300 tons per unit.

Separate welded, triangular booms are provided for each bucket trolley. Integrated design of the booms, with compression members into the tower, results in a structure of low height — 126 feet.

Find out more about how Dravo design and building know-how can help solve your coal or ship unloading problems. Contact DRAVO CORPORATION, Pittsburgh 25, Pennsylvania.

DRAVO
CORPORATION

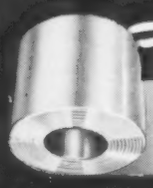


There IS a string attached to lower steelmaking costs . . .

A nylon string . . . that is the heart of the revolutionary new Lee Wilson Opened Coil Annealing System that promises to set annealing production records wherever installed.

The nylon string is ingeniously threaded between coil laminations, actually opening up the coil to permit the hot annealing gases free movement over every square foot of coil surface. In this manner heat can be applied to both sides of each wrap of the coil simultaneously—not through the mass of the coil. Consequently the coil can be brought to heat faster, more uniformly—soaked with precision—cooled faster with greater control.

The result: a better annealed steel at substantially increased man-hour production rates. It's the talk of the industry. Be sure you're fully acquainted with Opened Coil Annealing. Contact your Lee Wilson sales engineer or write for complete literature.



Lee Wilson® ENGINEERING COMPANY, INC.

HIGH PRODUCTION ANNEALING SYSTEMS

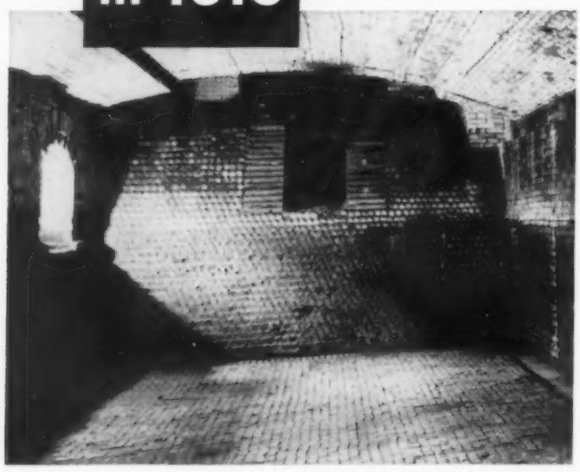
MAKE THE BEST METALS BETTER

® ORIGINATORS AND LEADING PRODUCERS OF OPENED COIL AND SINGLE STACK FURNACES

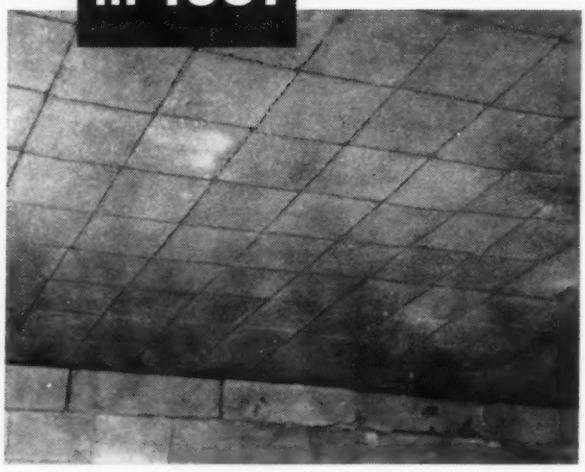
HARBISON-WALKER HISTORY OF PROGRESS IN REFRACTORIES FOR THE ALL-BASIC OPEN HEARTH FURNACE

Harbison-Walker Refractories Company from its first beginnings, in 1865, only several years short of a century ago, has closely worked with the iron and steel industries in the production of refractories needed to make possible the rapid evolutionary advances in furnace practice. This progress involves increased severity of operating conditions including much higher temperatures and larger furnaces with increased rates of production, accompanied by the use of oxygen with all its benefits. Rates of steel production based on sizes and designs of furnaces — noteworthy advances in metallurgical practice — and availability of superior refractories, in many instances, have been substantially increased.

in 1916



in 1931



QUOTATIONS FROM LITERATURE OF LONG AGO ILLUSTRATE HARBISON-WALKER'S LEADERSHIP

The Original METALKASE Basic Brick. From Harbison-Walker Manual 1916: "METALKASE BRICK, a refractory of ingenious form, developed and perfected through several years' service in actual open hearth practice. After its value in open hearth linings had been completely demonstrated, it was first placed on the market in 1916. These brick have been adopted with highly satisfactory results in many steel plants and under conditions for which they are best suited have given two to three times the service of magnesite brick and many times that of silica brick."

The First Suspended Basic Roof built for Harbison-Walker's pioneering research in 1931. From AIME Proceedings, Volume 106 (1933): "Almost nothing was known regarding the behavior of magnesite brick in suspended construction; the time required for safe heating and cooling, limiting temperatures at which hot patching could be attempted; the effects of relatively high thermal conductivity on hangers; probable heat losses; or the possibility of insulation. In order to secure needed data, an experiment was conducted at the plant of Harbison-Walker Refractories Company at Hays, Pa."

in 1923 . . . Chemically Bonded Basic Brick — In the year 1923 Harbison-Walker introduced the first chemically bonded magnesite-chrome refractory for which patents were granted in 1925. Through ensuing years, many millions of chemically bonded basic brick, a major portion of which were made with the metal casings, have become used as the standard type of basic brick in open hearth steel furnaces.

These important milestones of progress in basic refractories are typical of many others by Harbison-Walker.

Sprung Open Hearth roof of METALKASE 29-57 XXP at Homestead Works of United States Steel Corporation

TODAY...

Another Harbison-Walker Basic Open Hearth Roof among the many making service and tonnage records

With the all-basic open hearth furnace becoming an economical reality the production of new refractories having decidedly enhanced properties has been necessary. Harbison-Walker conventional and specialized basic refractories are fully meeting these requirements.

A fundamental factor in the achievement of the all-basic furnace is the metal encased basic brick pioneered more than forty years ago by Harbison-Walker. Through constant research and extensive application experience, rapid evolutionary progress has resulted in the successful use of the metal encased brick for the open hearth roofs as well as for other furnace parts. METALKASE 29-57 XXP internally plated metal encased brick are used in both sprung and suspended open hearth roof constructions of all designs with excellent service records.

An exceedingly important contributor to the excellence of this refractory developed specifically for this requirement, is the high purity magnesia produced by Harbison-Walker from Michigan brines. Fully stabilized as periclase of high density, it is an important constituent of this refractory having outstanding properties for the particular application.

The successful use of basic brick for roofs contributes to greater severity of conditions imposed upon other furnace parts. Harbison-Walker basic refractory products long established with unequalled records, together with the newer specialized brands, fulfill these rigid requirements for bottoms — walls — and regenerator checkers and make the ALL-INCLUSIVE, ALL-BASIC Open Hearth Steel Furnace a reality.

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and Subsidiaries

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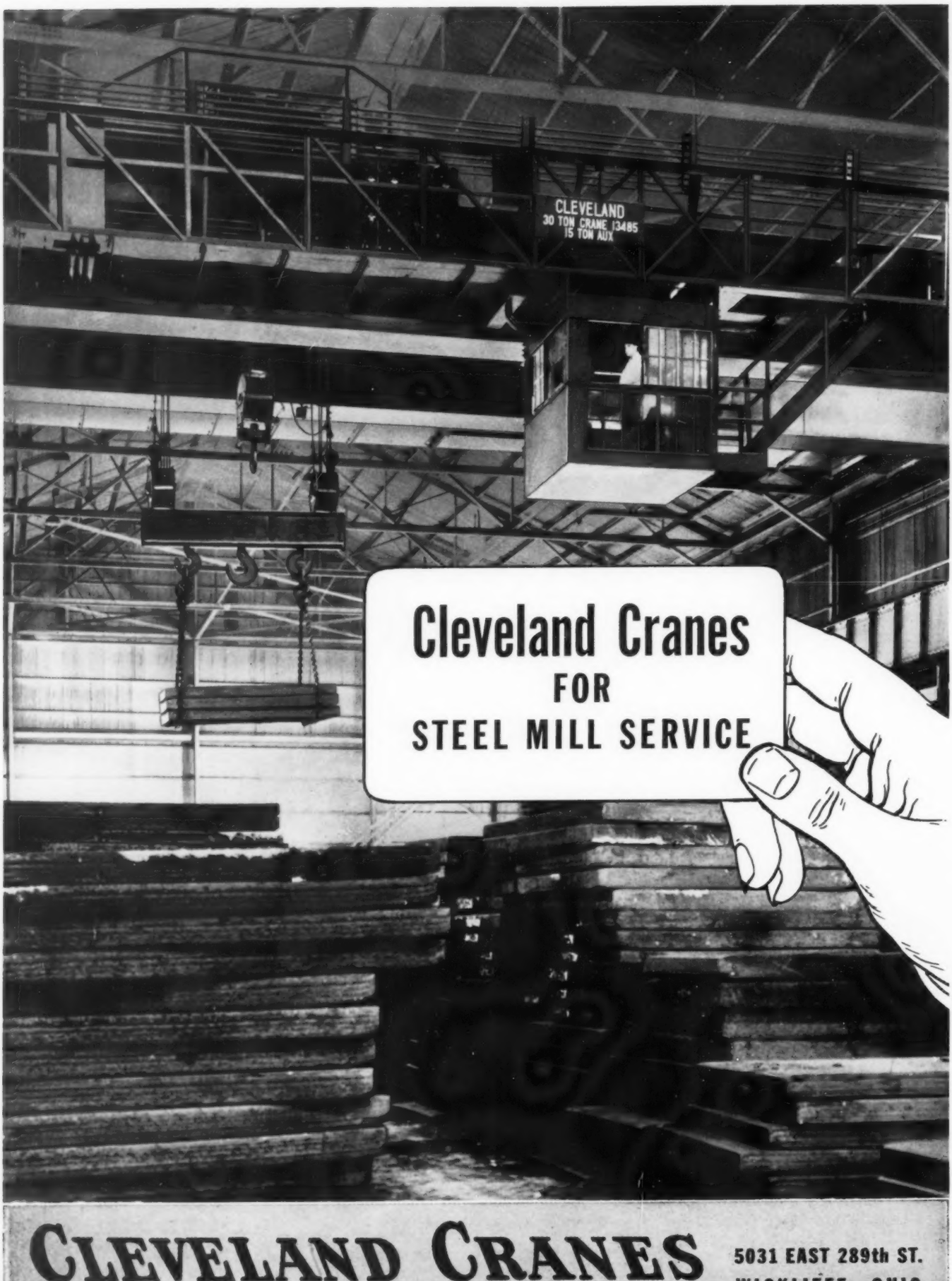
World's Most Complete Refractories Service



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

△ Roger M. Blough, chairman of United States Steel Corporation, says that every one-cent per hour increase in direct employment costs add some $15,000,000 a year to the industry's cost. Further, similar wage boosts in other industries raise the costs of purchased goods, services and taxes an equal amount. He states that employment costs in production from raw materials to finished product, direct and indirect, account for 75 to 80 per cent of all costs.

△ Joseph L. Block, chairman of Inland Steel Company, says the steel industry must strongly resist if the United Steelworkers union makes excessive demands in its wage negotiations this year. He feels that steel must do its part to help prevent further inflation, it must avoid pricing itself out of its own market here and out of foreign markets, it must not allow itself to be weakened and it must resist excessive wage advances because freedom itself is at stake.

△ The Office Economist says we hear too much about higher standards of living and not enough about higher standards of life.

△ A Chicago correspondent sent us a letter written by a retired steel worker to the editor of the Chicago Daily News. An excerpt: ". . . it is this vicious spiral (price-wage) which is contributing more than anything else to the eventual mutilation of our economy . . . From my steel union experience, I'm sure that the vast majority of the steelworkers really want wage stability, and are heartily sick of these periodic strikes. Their so-called strike votes are an absolute farce and as a matter of fact they are practically nonexistent. The trouble lies with Congress and its inability so far to enact the proper legislation insuring the individual union member his proper rights."

△ Another letter recently published in a Pittsburgh newspaper describes the $1,000,000,000—for—steelworkers advertising campaign as "the most brazen disregard of our country's greatest danger yet evidenced by any union."

△ Right now a number of union leaders are concerned because their memberships are lower than they were a year or so ago. Yet they will not recognize that the higher wages go, the easier it becomes to justify economically the purchase of labor-saving machinery.

△ B. F. Fairless has emphasized that "what we need is not just more *in* pay envelopes but also more envelopes; not just more for each job but also more jobs for more people."

△ The Bureau of Yards and Docks of the U. S. Navy Department is requiring its builders of box girders for overhead cranes to conform to the applicable parts of the crane specifications of the Association of Iron and Steel Engineers.

△ A research report presented by American Can Company at the National Canners Association predicts that aluminum cans will be used increasingly where the metal provides some special advantage. Future price of aluminum is the key. The price is now approaching that of tin plate on a gage-for-gage basis. Aluminum will find its first use in cans for products not requiring thermal processing, where aluminum can replace tin plate of the same gage. However, to provide the same paneling resistance and buckling resistance as tin plate containers for processed foods, the gage of aluminum containers must be increased by 35 per cent. At present, aluminum also has a tendency to bleach some of the highly pigmented products.

△ Vinyl-coated steel sheets in any color and in several standard textures are being produced by United States Steel Corporation. This material is attractive and should find a lot of applications.

△ Marcus J. Aurelius, administrative vice president of United States Steel Corporation, told the Purchasing Agents Association that, in every decline in steel output, at least half of the drop has been attributable to the change from steel stockpiling to stock reduction. He believes our economy would strengthen immeasurably if steps could be taken to stabilize steel purchasing procedures.

△ By the same token, a good part of the present steel boom is going to build up depleted inventories. Present indications are for a first-half production of about 60,000,000 tons of ingots, and about 50,000,000 tons for the second half.

△ Money isn't everything—plentiful, for instance. And there are bigger things than money—like bills.

△ Governmental budget season is upon us, and every one we've seen—local, state, federal—is higher and is accompanied by new or increased taxes. It's time that governing agencies begin to ask "Is it necessary?" instead of "Is it desirable?" or "What will it do for me?" But they seem to think that public apathy means approval and go on blithely spending and taxing.

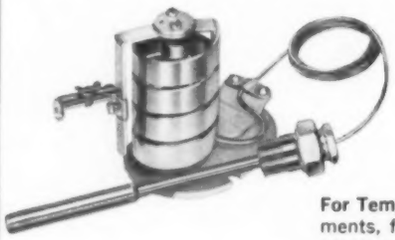
△ Porous stainless steel, made by Crosley Division, Avco Manufacturing Corporation, is buoyant in water.

△ For the first time in seven years, enrollment in American engineering schools has declined. The 153 accredited engineering colleges had 2.9 per cent less students, and 11.6 per cent less freshmen, in the fall of 1958 than in the fall of 1957.

TYPICAL MOTION-TYPE TRANSMITTER MEASURING ELEMENTS

For Flow and Liquid Level — Type 37 Mercuryless Diaphragm Element. Ranges from 20 to 200 inches water.

For Pressure — Helical Elements, with ranges from 0-200 to 0-6000 psi. Ranges from 10 inches water to 80,000 psi available with other Foxboro pressure elements.



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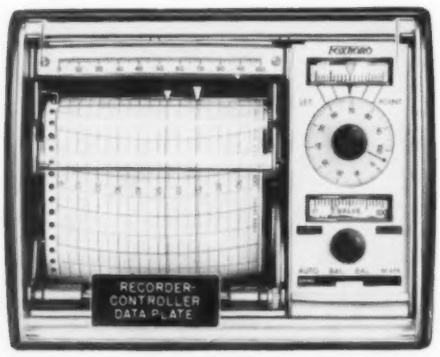

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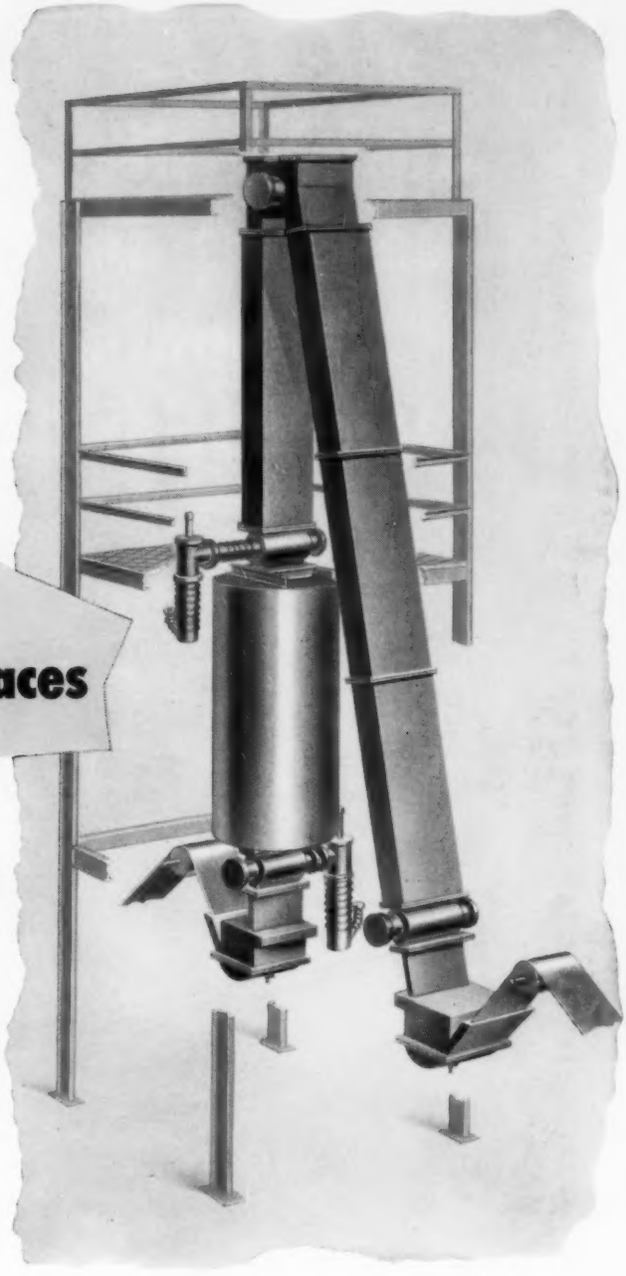

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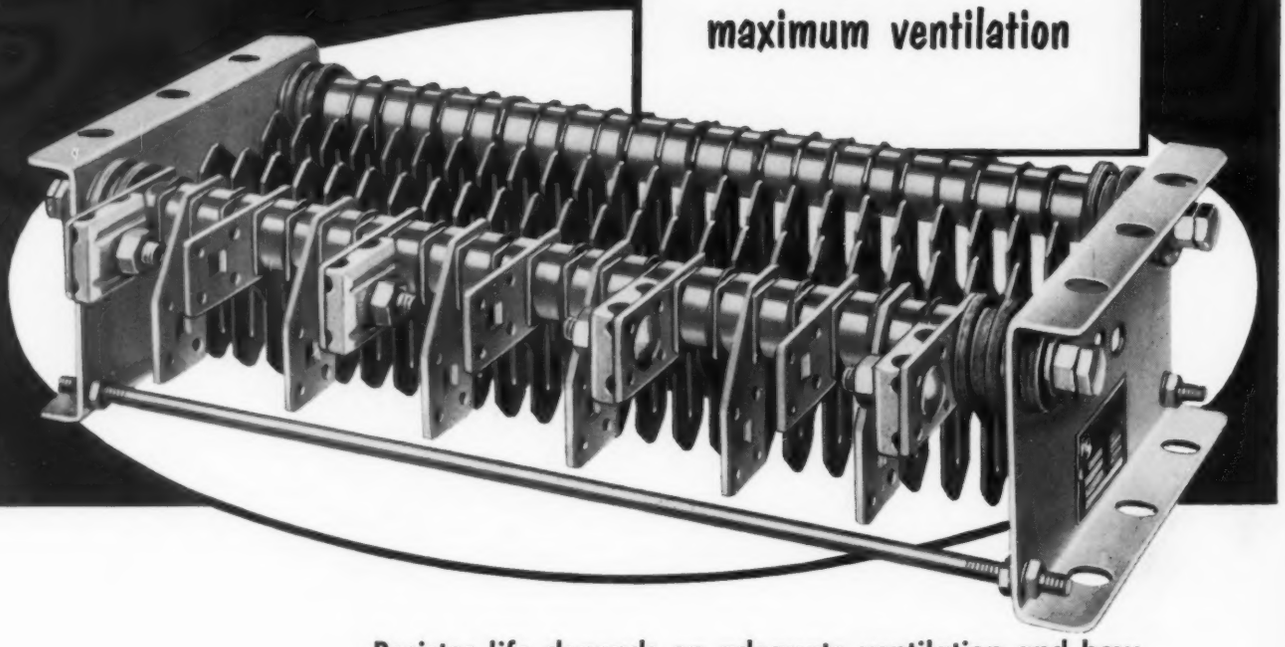

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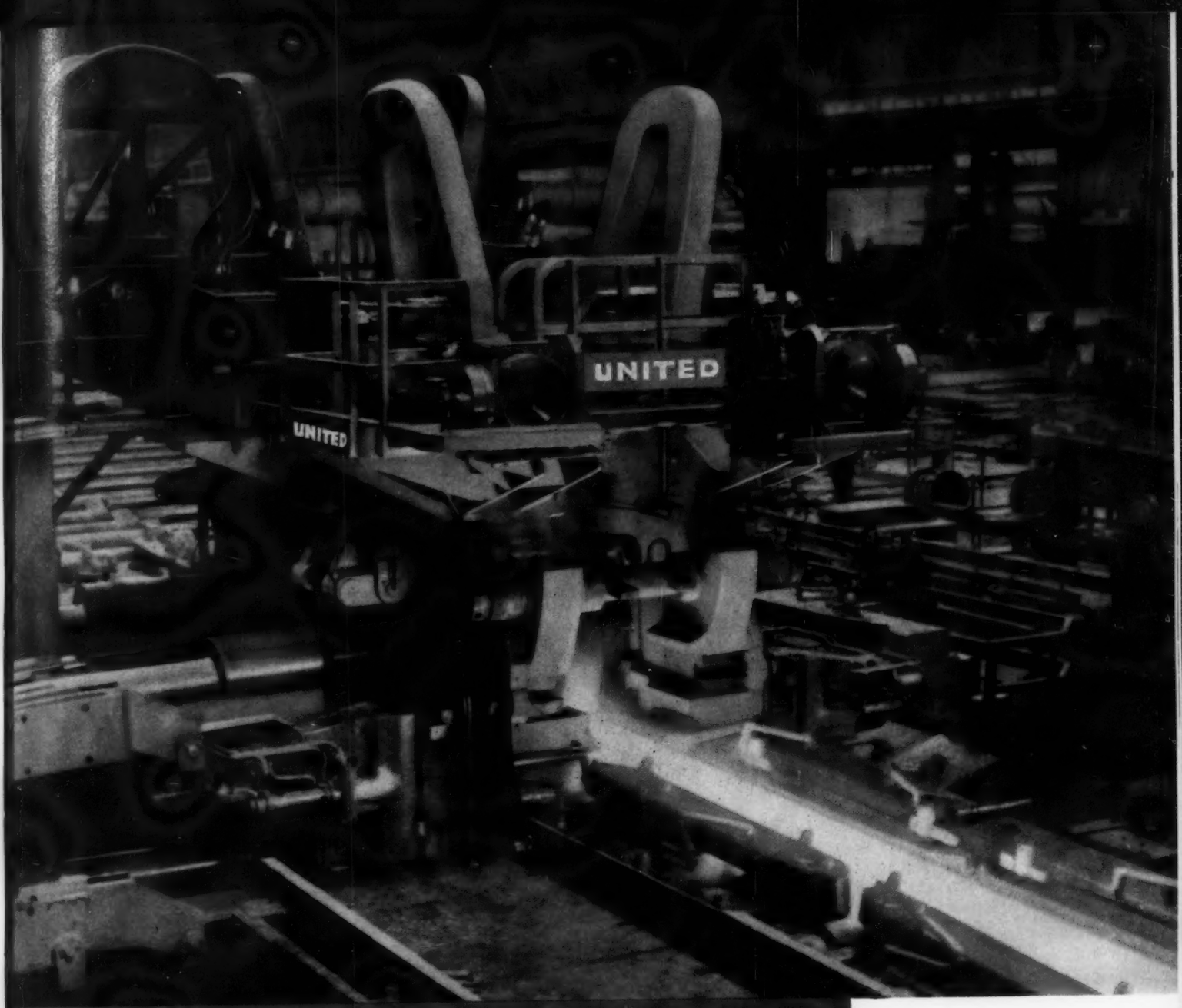

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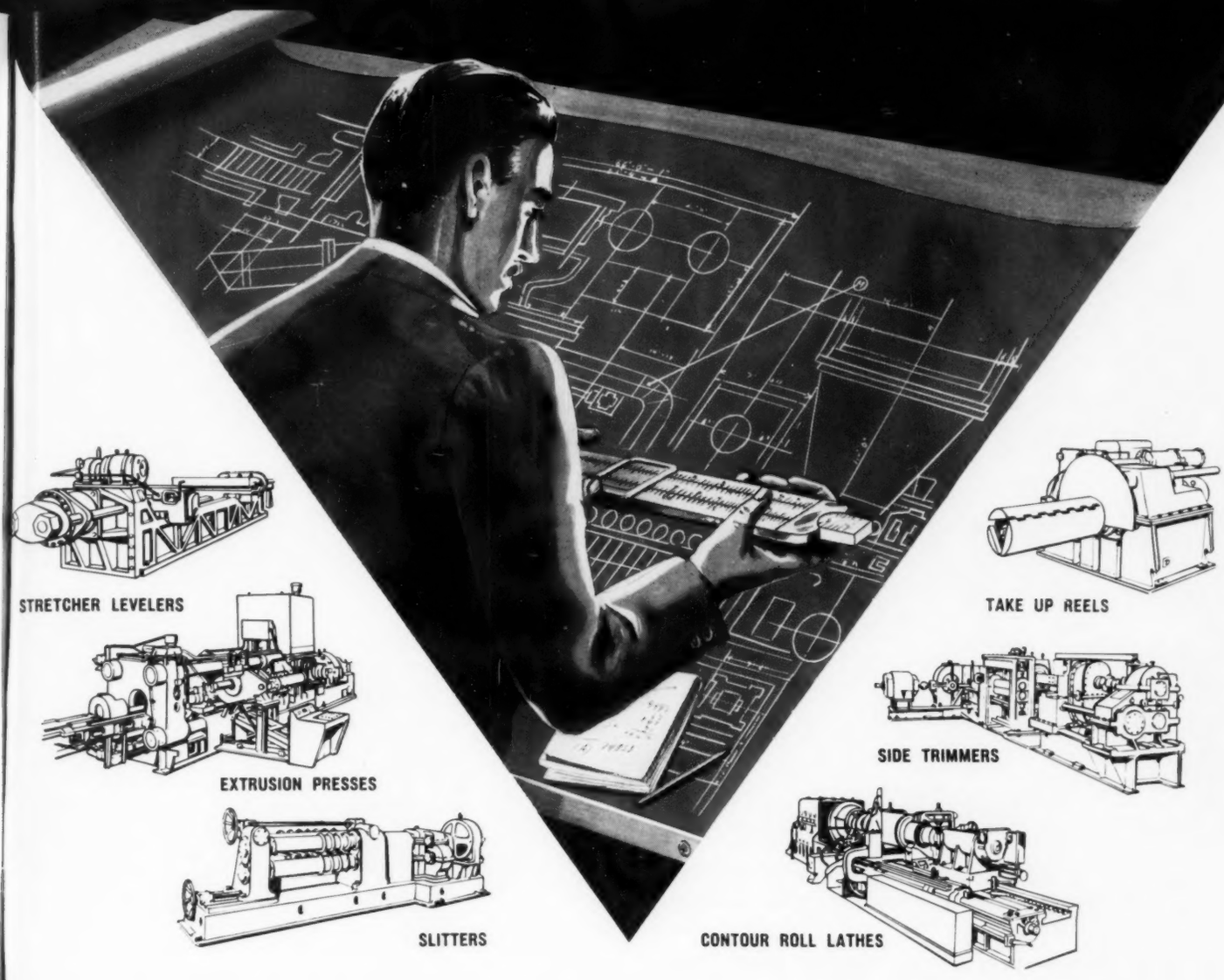

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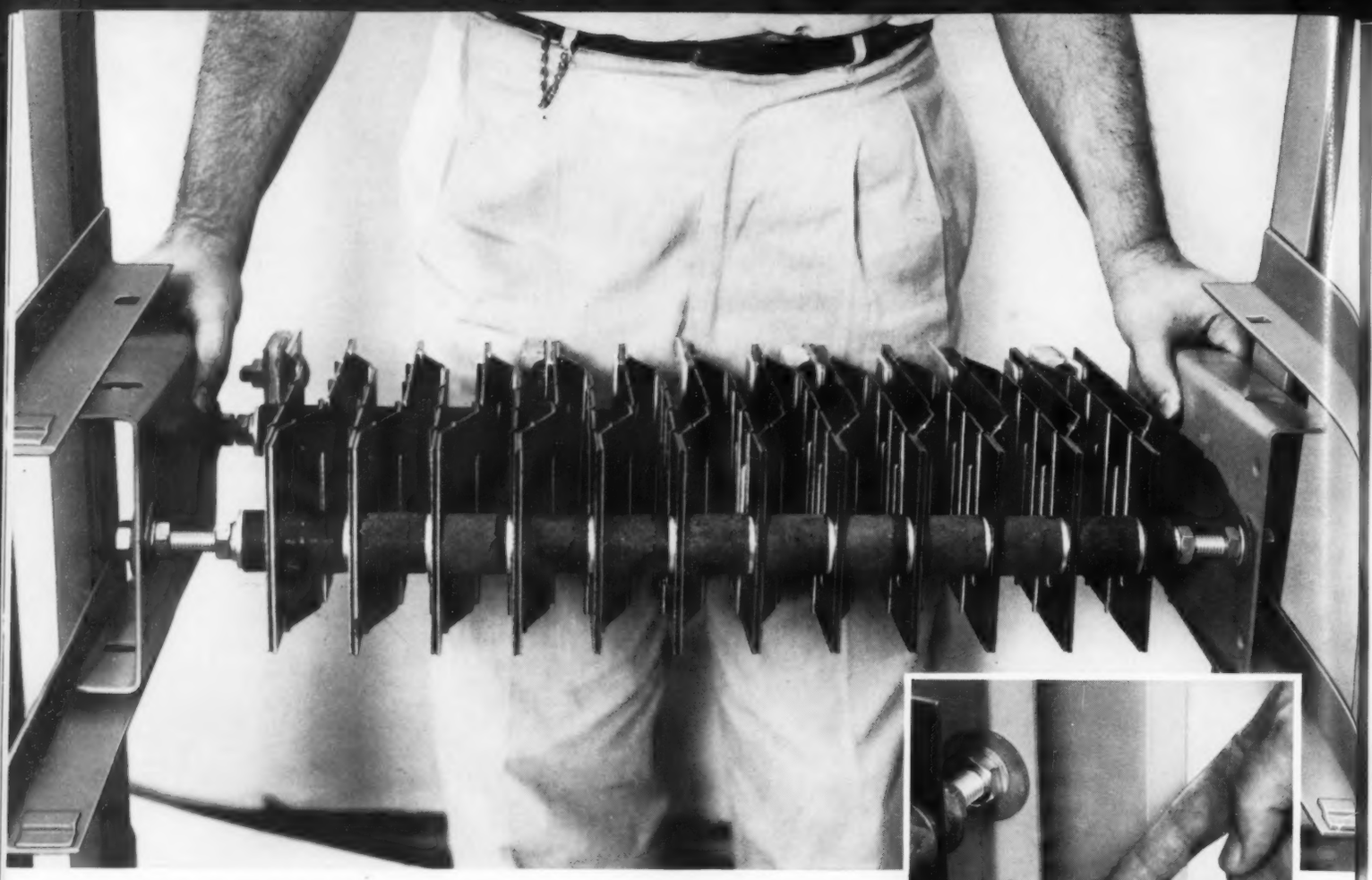

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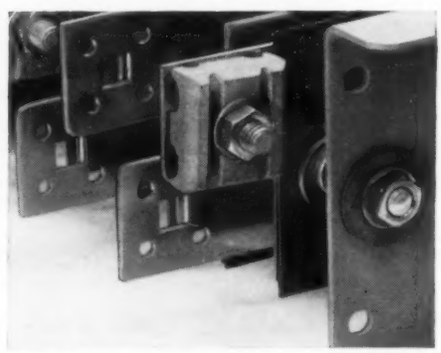

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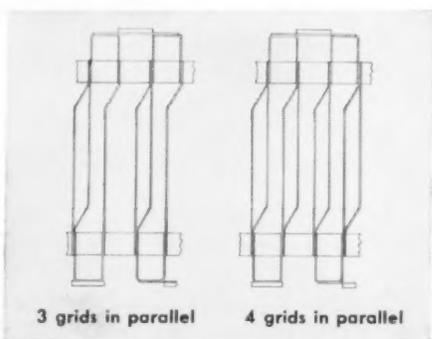

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patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period October 7, 1958 through October 28, 1958

CONTINUOUS CASTING OF STRIP, WIRE, OR TUBE

△ U. S. 2,854,732, issued Oct. 7, 1958, to Wilfrid C. F. Hessenberg and assigned to the British Iron & Steel Research Association, relates to the production of metals in elongated form, e.g., in the form of strip, wire or tube by continuous casting.

The principle on which the invention works may be illustrated by the following example. If a piece of relatively cold metal is immersed in a molten bath of the same metal, heat will immediately flow from the contacting part of the melt into the cold piece; and a portion of the liquid metal will solidify and form a crust surrounding the piece. At this state, the piece must be withdrawn, or the crust will remelt if more heat is permitted to flow into it. Eventually the piece itself will melt.

In Figure 1 the core material consists of steel strip 10 which has been freshly descaled and cleaned by an acid, such as sulphuric acid.

The core material 10 is led from the coil 11, which is positively driven, and passes between the

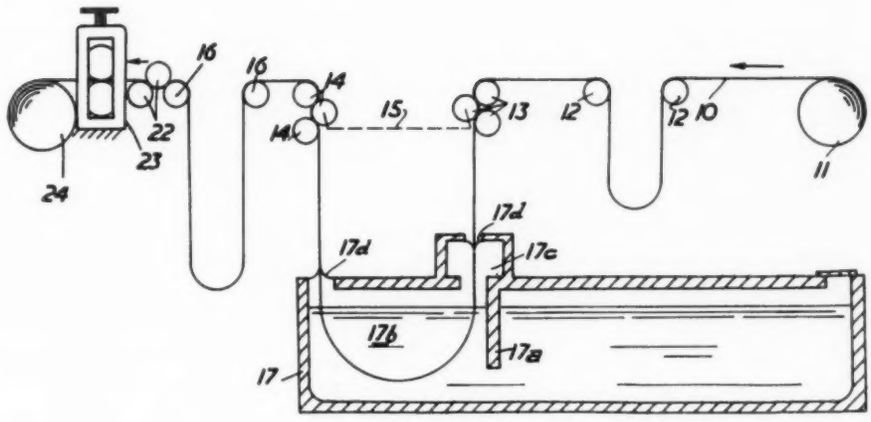


Figure 1

bridle rolls 13 which control the speed at which the strip 10 passes into a holding furnace or bath 17 containing molten steel. A loop of the material 10 is formed between guide rolls 12 to accommodate any slack arising from the difference in speed at which the material leaves the coil 11 and that at which it passes through the bridle rolls 13.

The material 10 leaving the bridle rolls 13 is drawn through the furnace 17 by the bridle rolls 14. The bridle rolls 13 and 14 are linked (as indicated symbolically by the link 15), either mechanically or electrically so as to maintain a given length of the material looped into the molten steel of furnace 17.

The furnace 17 contains a weir 17a which prevents entrance of slag to the casting chamber 17b. The casting chamber 17b has a gas cover 17c through which the material 10 enters the furnace with suitable gas sealing means 17d provided between the material 10 and the openings through which it enters and leaves the furnace 17.

During its passage through the molten metal in the bath, a crust will be formed on the material 10 as explained above. The temperature of the material and the bath and the

rate of passage of the material through the melt are adjusted so that it leaves the furnace covered by a substantial deposit of the solidified melt.

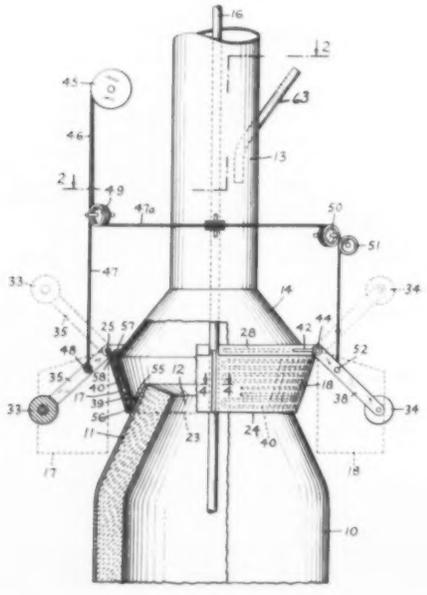
After leaving the bridle rolls 14 by which the material 10 is drawn from the furnace 17, another loop is formed between guide rolls 16. As the material passes between the rolls 16, it may be cooled if the material is to be put in temporary storage or reheated if its thickness is to be reduced by hot working. In the present example the material is shown passing via bridle rolls 22 to a rolling mill 23, where its thickness is reduced and then formed into a coil 24.

SYSTEM FOR SEALING AN OXYGEN CONVERTER

△ U. S. 2,855,194, issued Oct. 7, 1958, to Walter Konig, assigned to Brassert Oxygen Technik A. G., describes a system for facilitating the recovery of valuable waste gas developed during the converting operation and for recovering dust and iron oxides from the converter.

Waste gas is developed during refining of metals in a converter. This gas escapes mainly into the atmosphere. When pig iron is converted into steel by blowing it with pure oxygen from above, large quantities of waste gas are created which, being principally carbon monoxide, burn at the mouth of the converter. The waste gas also carries finely divided oxide with it, thereby creating a nuisance as well as constituting a waste of a valuable product.

Figure 2



In order to minimize the loss of carbon monoxide and other dust, it is necessary to keep the volume of gas issuing from the converter as small as possible and to collect the gas in an unburned state at the mouth of the converter. If the gas is allowed to mix with air, it will burn with the result that nearly ten times as much gas will be produced as that initially issuing from the converter. The gas thereby produced is of little value, and its volume is so great that it cannot be handled economically for recovery of metallic oxides.

As shown in Figure 2 a converter includes a cylindrical shell 10 of sheet steel containing a brick liner. The shell is mounted for pivotal movement around a horizontal axis and has a tapered nose portion 11 which is provided with a filling and pouring opening or mouth 12. The installation also includes a smoke pipe 13 alined with the vertical blowing axis of the converter 10. The smoke pipe has a flared hood 14 at its lower end overlying the mouth of the converter but spaced therefrom to enable the converter to be tilted for charging, blowing and pouring.

Extending down through the center of the smoke pipe is an adjustable lance 16 through which oxygen is introduced into the bath of the converter. The lance 16 can be moved up and down by means of a hoist (not shown). This allows it to be withdrawn from the converter during tilting. This allows moving the lance into its proper relationship with the charge in the furnace.

The present invention provides a mechanism for sealing the gap between the mouth of the converter and the lower edge of the hood 14. The sealing mechanism includes two or more collar sections 17 and 18 which are identical and which together form a complete collar capable of encircling and engaging the edge of the hood 14 and the shell adjacent to the mouth of the converter. When in the positions shown in Figure 2 the sections 17 and 18 close the gap between the lower edge of the hood and the converter shell to prevent substantial air entry into the gas stream flowing from the converter mouth into the smoke pipe 13.

COLLECTION OF DUST FROM OXYGEN CONVERTERS

△ U. S. 2,855,292, issued Oct. 7, 1958, to William A. Vogt, assigned to Henry J. Kaiser Co., relates to the collection of dust from the gases leaving oxygen converters.

In Figure 3, a steelmaking vessel 1 of the bessemer type is indicated in the upright or blowing position. A sealing member 11, of ring form, encircles the upper or discharge end of the vessel 1 in clamping relationship and serves to confine the gases emitted by the vessel and direct their movement to a duct 12 communicating with a gas cooling and conditioning tower 2.

The gases entering the tower 2 are at a temperature of approximately 3000 F and are dust-laden with iron oxides as a result of the

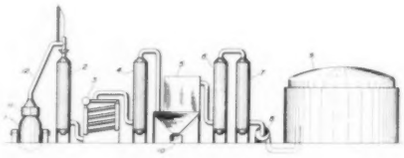


Figure 3

vessel blowing operation. It is the purpose of the conditioning or cooling tower 2 to rapidly lower the temperature of the gases to a point, not over 2500 F, where no iron oxide reactions can take place with the CO gas. The gases are rapidly cooled in this zone by introduction of a water spray. The gases are then conducted to waste heat boiler 3.

In their passage through the waste heat boiler the gases give up a relatively large amount of their sensible heat which would otherwise be lost to the surrounding atmosphere. They leave the boiler at approximately 600 F. It is the ultimate purpose of the present system to store the CO gas for use as a fuel. However, in its condition as it leaves the boiler, it is still dust laden, has a high moisture content, and must be further cooled before filtering.

A temperature control tower 4 is provided for the reception of the gases leaving the boiler 3. At this stage their temperature is further reduced to approximately 275 F. They then pass to a filter 5 where the bulk of the suspended particles of iron oxide dust are removed. Leaving the filter the gases still retain traces of the finer particles of

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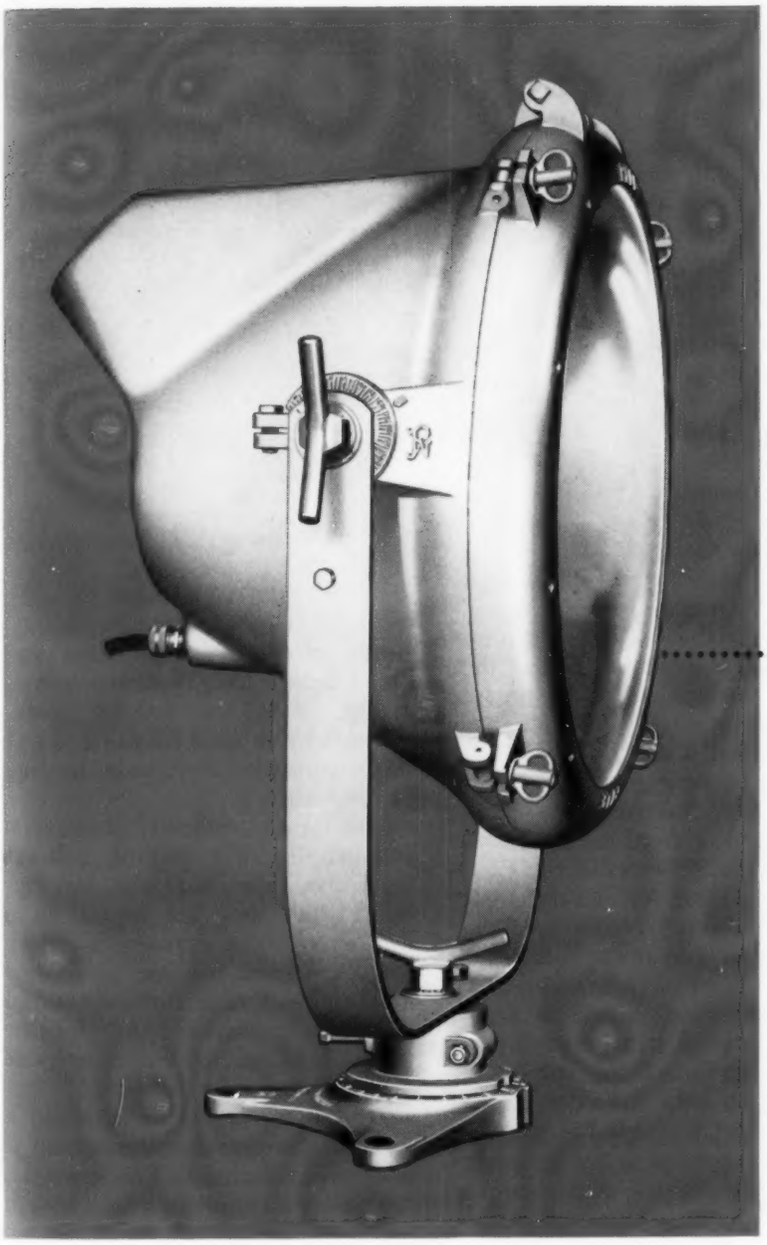

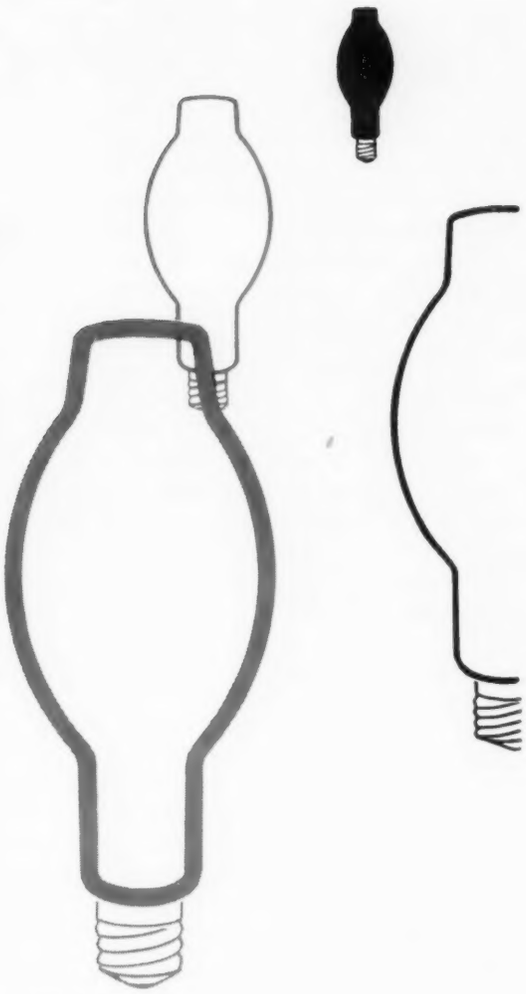

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dust and are relatively humid. The filtered gases are then passed through a washing tower or scrubber 6 to lower the temperature of the gases below their dew points thus precipitating the fine particles of dust that have been carried along to this stage.

Final conditioning of the gas takes place in a drying tower 7, where entrained moisture is removed; and under the action of an induced draft fan 8, the gases are discharged into a storage tank 9 for future use as fuel.

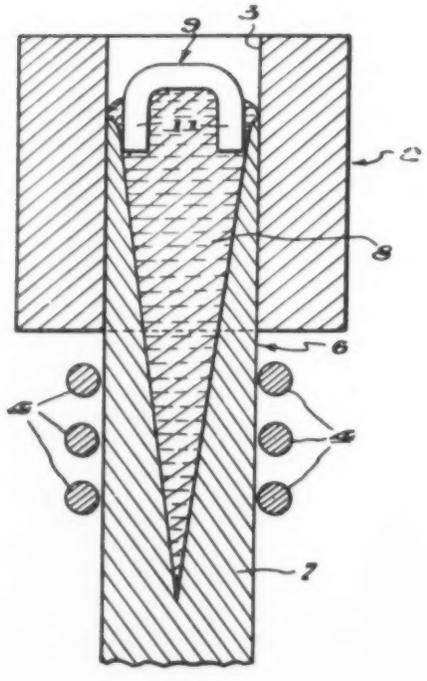
A pug mill 10 has been indicated below the filter unit 5. Provision can also be made at the base of all towers for the handling of solid matters precipitated, filtered and collected at these points.

CONTINUOUS CASTING PROCESS

△ U. S. 2,856,658, issued Oct. 21, 1958, to Rufus Easton and assigned to Koppers Co., Inc., describes a method of continuously casting molten metal in a casting run so as to avoid metal spillover at the end of the run.

In the continuous casting of molten metals and particularly in the casting of molten steel, it has been necessary to delay the downward removal of the solidifying casting from its mold until solidification of the casting core is complete. During this solidification

Figure 4



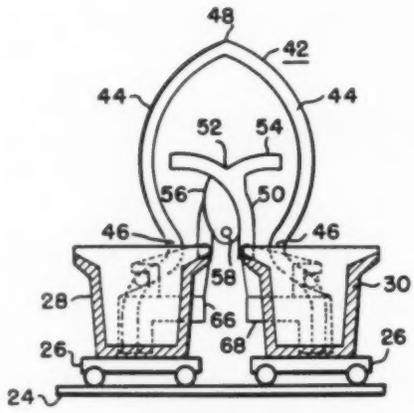


Figure 5

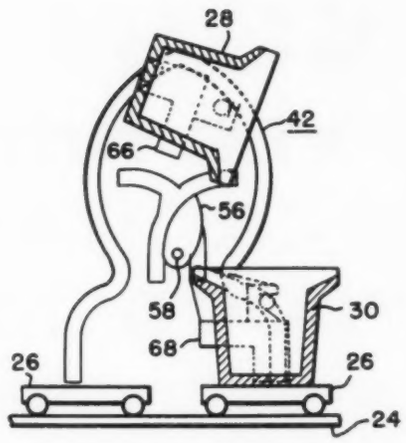


Figure 6

period there frequently occurs an inward bending or bowing of the solidifying shell toward the longitudinal axis of the casting. This bending causes the molten core metal to spill over the shell sides. The spillover runs down between the mold and the shell wall, past the bottom of the mold and damages the spray and roller system.

In Figure 4 an open-ended mold 2 is shown. The mold has an inner wall 3. A number of spaced supports and guide rollers 4 are positioned below the mold.

A supply of molten metal has been furnished to mold 2 from a tundish nozzle (not shown) in a typical casting run. As can be seen in the drawing, the casting in the mold, designated by reference numeral 6, has developed a solidifying shell 7 which surrounds molten metal core 8. To prevent the solidifying shell in the mold 2 from bending and buckling inwardly with resultant molten metal spillover, a supporting unit 9 has been inserted into the molten metal core at the end of the run.

The supporting unit 9 is a C-shaped piece of bent, round iron bar, the legs 11 of the bar being positioned to hold the sides of the shell 7 against the wall 3 of mold 2.

With the supporting unit properly inserted, the metal continues to solidify; but the supporting structure resists any inward bending of the solidifying shell 7, thus preventing any spillover of the molten metal core 8.

LADLE MIXING APPARATUS

△ U. S. 2,857,156, issued Oct. 21, 1958, to Andre Greffe, assigned to Societe d'Electro-Chimie, d'Electro-Metallurgie et des Acieries Electriques d'Ugine, describes an apparatus for flexibly handling two or more ladles for pouring the contents of either one to the other, and back and forth between the two to provide an intimate mixture.

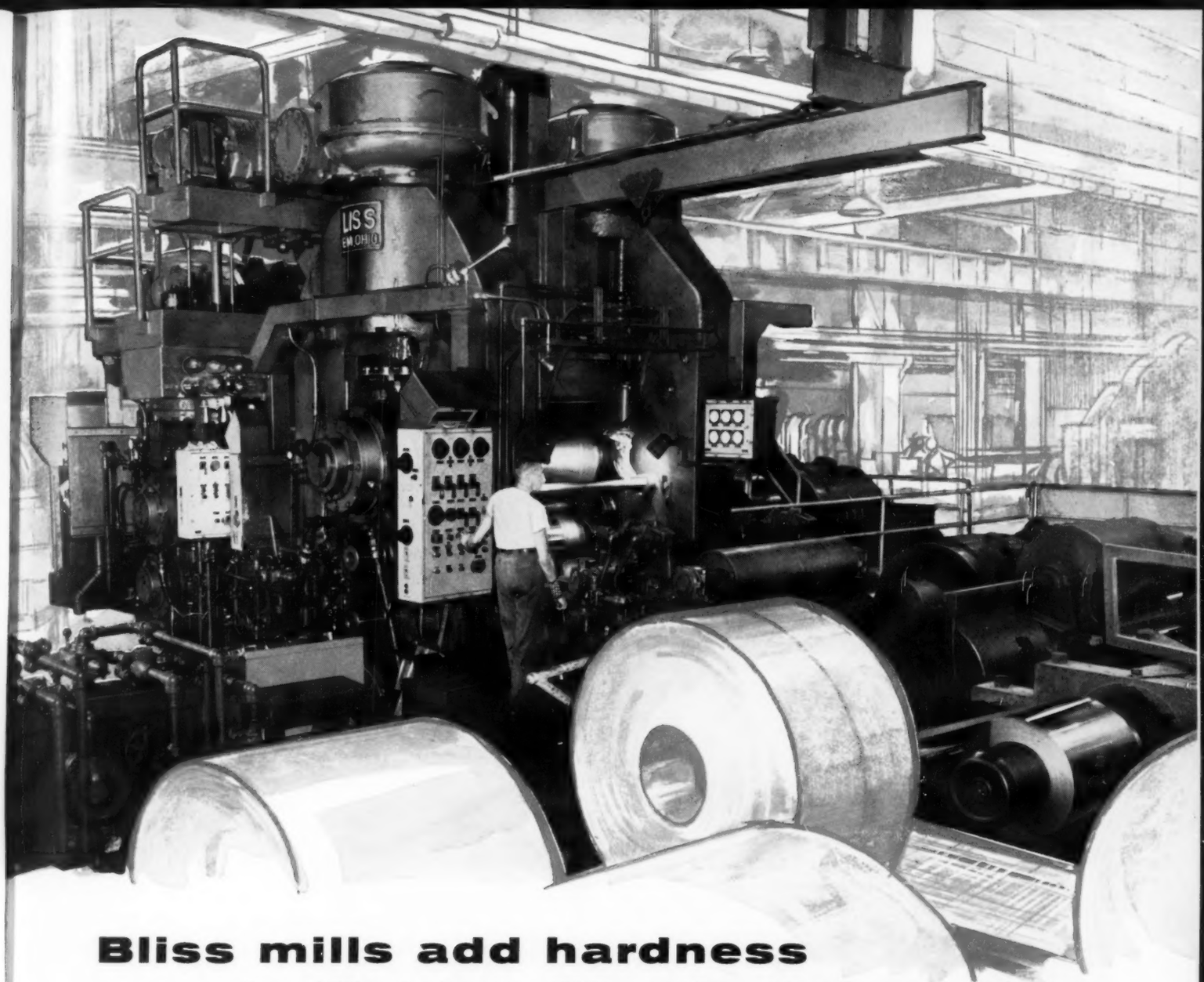
Figure 5 shows the mixing apparatus. Figure 6 shows the mixing apparatus in another phase of operation.

CONVEYING APPARATUS

△ U. S. 2,858,122, issued Oct. 28, 1958, to Charles MacGregor, assigned to York Engineering and Construction Co., describes a conveying table for moving workpieces such as steel tubes, bars and billets through a continuous heating furnace.

Heretofore, difficulty has been encountered in obtaining uniform heating of tubes, bars, etc., particularly when they are heated in a continuous type furnace in which workpieces are fed one at a time into one end of a furnace, moved transversely across the furnace during heating, and withdrawn one at a time from the exit end.

It is not possible to maintain a uniform temperature throughout a continuous furnace. For example, temperatures adjacent to the hearth are nearly always different from the temperatures adjacent to the roof. Therefore, unless the work is rotated, temperature uniformity will not be had. Rotating the work has heretofore been a difficult operation and has never been satisfactorily done. One reason is that the necessary equipment for rotating the work requires large openings in the hearth. These openings permit drafts



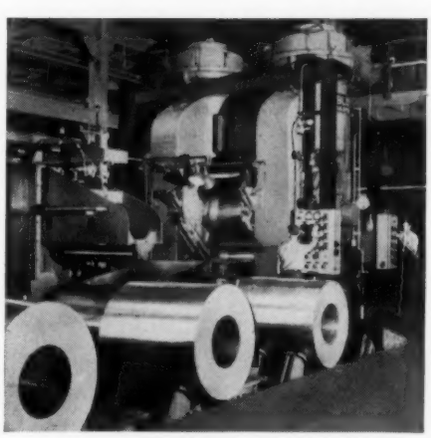
Bliss mills add hardness to Weirton Steel's line of strip

Weirton Steel Co., Division of National Steel Corp., the nation's largest independent producer of tin plate, uses a Bliss mill to achieve exacting temper and quality of its strip prior to plating. It is a four-high, two-high two stand tandem mill recently installed in its Weirton, W. Va., plant.

Through this unit Weirton has rolled a wide variety of steels in gages ranging from .00435 to .0147 inches and at an average maximum speed of 4,500 feet per minute. Well known products such as Weircote and Weirzin zinc coated steel are just two of Weirton's steel products to which this mill contributes.

A second Bliss mill tempers high-carbon, high-phosphorous, deep-drawing and galvanizing steels at the rate of 800 tons a day, while a new Bliss 48-inch slitting line is used to slit galvanized steel in gages from .0135 to .135 inches at speeds of 200 to 1,000 fpm. Both rolling mills are equipped with Amerigear-Bliss spindles.

These three installations provide one more example of the ready acceptance of the name of Bliss in the rolling mill industry—both here and abroad. To learn how Bliss equipment can help increase your rolling capacity, simply write for our new 84-page Rolling Mill Brochure, Catalog 40-B.



Four-high temper mill handles 30,000-lb. coils at speeds up to 3,500 fpm...has rolled 1,000 tons in a single day. Back-up rolls were supplied by Bliss' Mackintosh-Hemphill Division.

BLISS
SINCE 1857

Bliss is more than a name . . . it's a guarantee

E.W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

of cold air to enter the furnace through the hearth, making it impossible, or at least difficult, to control the furnace temperatures. This creates cold spots on the portions of the work above the openings in the hearth.

These difficulties are overcome in the present apparatus. As shown in Figure 7 tubes 18 are brought to a furnace 19 and fed through an entry port 19a onto conventional skewed rollers 20, each driven by a drive 21. The rollers 20 carry the tube along one side and to the end of the furnace where it engages a bumper 22. The rollers 20 not only advance the tube along the side of the furnace, but they also rotate it about its axis. This rotation keeps the tube straight and also takes out camber which might have developed in the tube before it was brought to the furnace.

Kickups 23 lift the tube off the rollers 20 and place it on stationary racks 24 which extend parallel to each other and across the furnace above the hearth. Movable racks 25, parallel and adjacent to the racks 24, are then actuated to raise the tubes off the stationary racks 24 and deposit them back on the stationary racks at a point closer to the other side of the furnace. The tubes while moving across the racks are also rotated about their own axes. This action continues until the tube has been moved the full width of the furnace, where it rolls off the ends of the stationary racks onto another set of skewed rollers 26, driven by drives 27. These rollers move the tube out through an exit port 28 in the end of the furnace opposite the entry port. The rollers 26 also rotate the tubes about their axes. In operation the racks are filled to capacity with pipe sections so that when a tube enters the entrance port 19a, another tube leaves the exit port 28. The speed of operation can be varied to regulate the heating time for the particular size of workpiece being heated.

Figure 8 is a cross-sectional view along the lines II-II of Figure 7.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or assignee
2,855,150	10/7/58	Device for counting sheets	United States Steel Corp.
2,855,290	10/7/58	Reduction of iron oxide to sponge iron	Freeman Corp.
2,855,291	10/7/58	Slag conditioning agent	Foote Mineral Co.
2,855,296	10/7/58	Method of sintering nickel powder	General Motors Corp.
2,855,336	10/7/58	Manufacture of nodular iron	Thomas W. Curry
2,855,644	10/14/58	Ingot mold mat	Harrison D. Sterick
2,857,019	10/21/58	Apparatus for lubricating blooming mills	Trabon Engineering Corp.
2,857,155	10/21/58	Reduction of iron ore to iron powder	Electrolyser Corp. Ltd.
2,857,299	10/21/58	Heat treating of steel	Bethlehem Steel Co.
2,857,300	10/21/58	Process for coating and hardening steel	American Metallizing Corp.
2,857,301	10/21/58	Surface hardening of steel	Reed Roller Bit Co.
2,857,444	10/21/58	Gas collection from electric smelting furnaces	Elektrokemisk A/S
2,857,642	10/28/58	Continuous metal melting	Selas Corp. of America
2,857,655	10/28/58	Apparatus for processing continuous metal strip	United Engineering & Foundry Corp.
2,857,731	10/28/58	Manufacture of wire rope	United States Steel Corp.
2,857,820	10/28/58	Machine for trimming fins from ingot molds	Valley Mould & Iron Corp.
2,858,204	10/28/58	Sintering iron ores	Metallgesellschaft A. G.
2,858,206	10/28/58	Nickel-free, low-alloy, high-strength steel	United States Steel Corp.
2,858,243	10/28/58	Production of improved free machining steels	La Salle Steel Co.

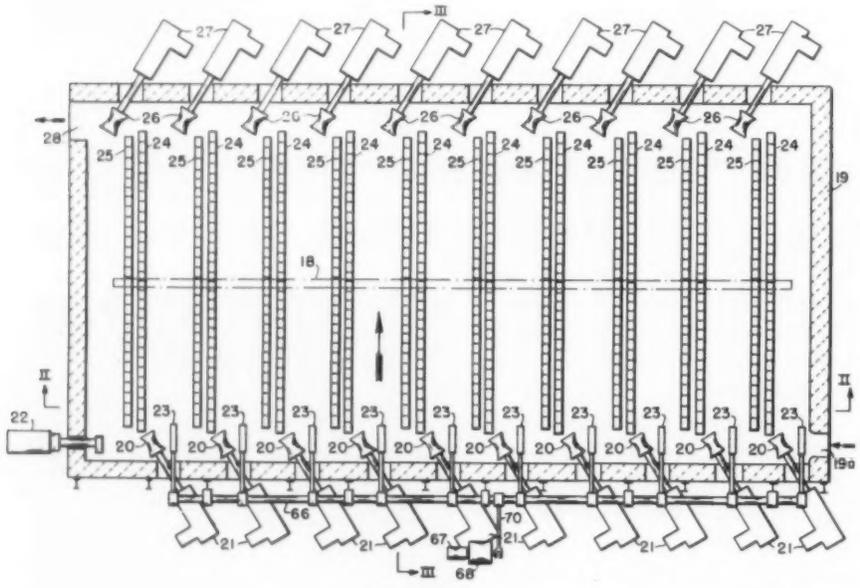
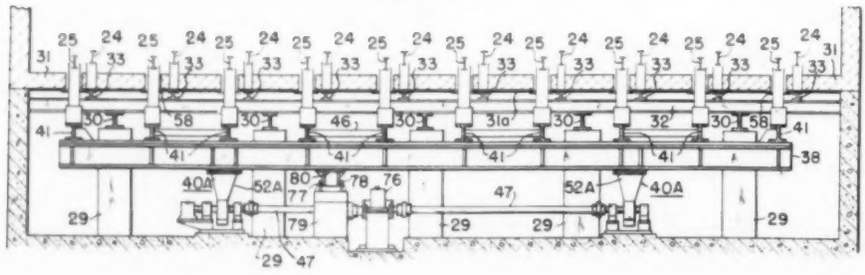


Figure 7

Figure 8



OXYGEN CONVERTER PROCESS

△ U. S. 2,856,280, issued Oct. 14, 1958, to Ludwig A. von Bogandy, assigned to Huttenwerk Oberhausen A. G., describes a method of pre-refining highly carburized pig iron melts by means of a blast rich in oxygen. The object is to avoid the formation of fine-grained dust.

It has been found that dust is developed in oxygen converters only when carbon is made to burn. It is believed that this is due to the fact that the CO bubbles formed during the oxidation of the carbon act as carriers of Fe vapors. In order to eliminate the accumulation of dust in the melt, the operation is carried out in a vessel covered with a smooth surfaced coat of slag.

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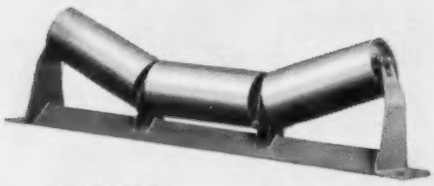

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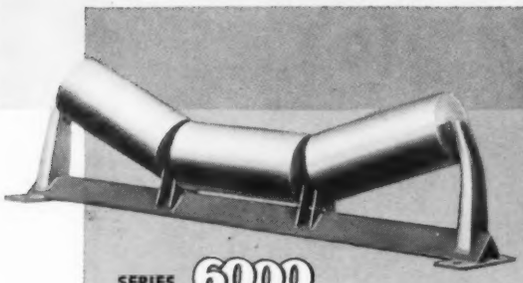
For intermittent or light service . . . for fine or small lump materials. 14- to 30-in. belt widths. Equipped with commercial ball bearings.



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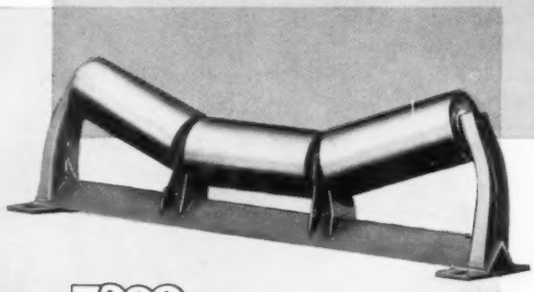
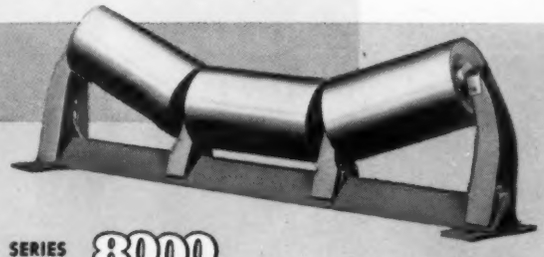
For intermittent operation, medium capacities, and for moderate weight, semi-abrasive materials—or for continuous operation handling lightweight, fine material. 14- to 48-in. belt widths. Available with greaseable or factory-sealed precision type ball bearings.



SERIES 7000

For continuous operation . . . high capacities . . . heavy-weight, abrasive materials. 18- to 48-in. belt widths. Equipped with precision roller bearings.



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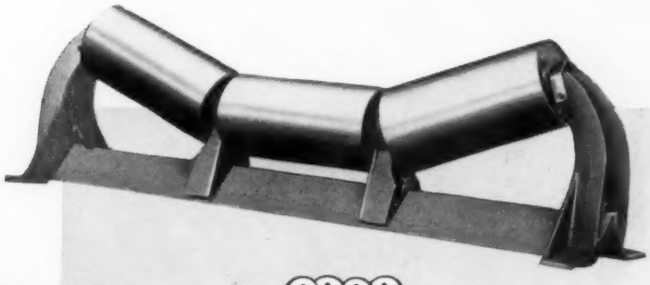
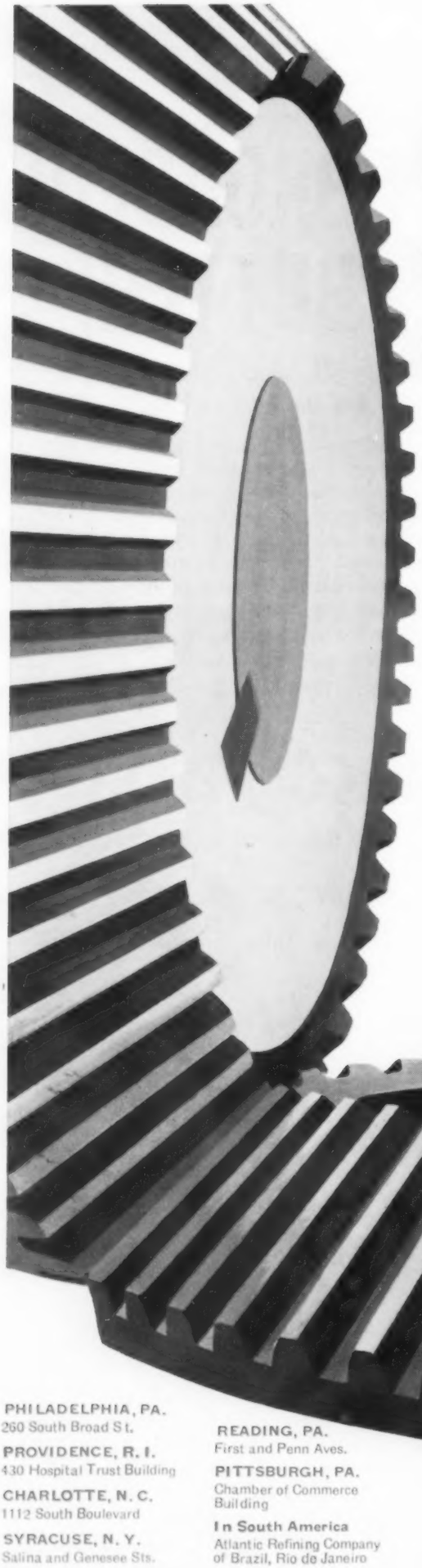


SERIES 9000

For continuous service . . . highest capacities . . . heaviest and coarsest materials. 36- to 84-in. belt widths. Equipped with heavy-duty precision roller bearings.



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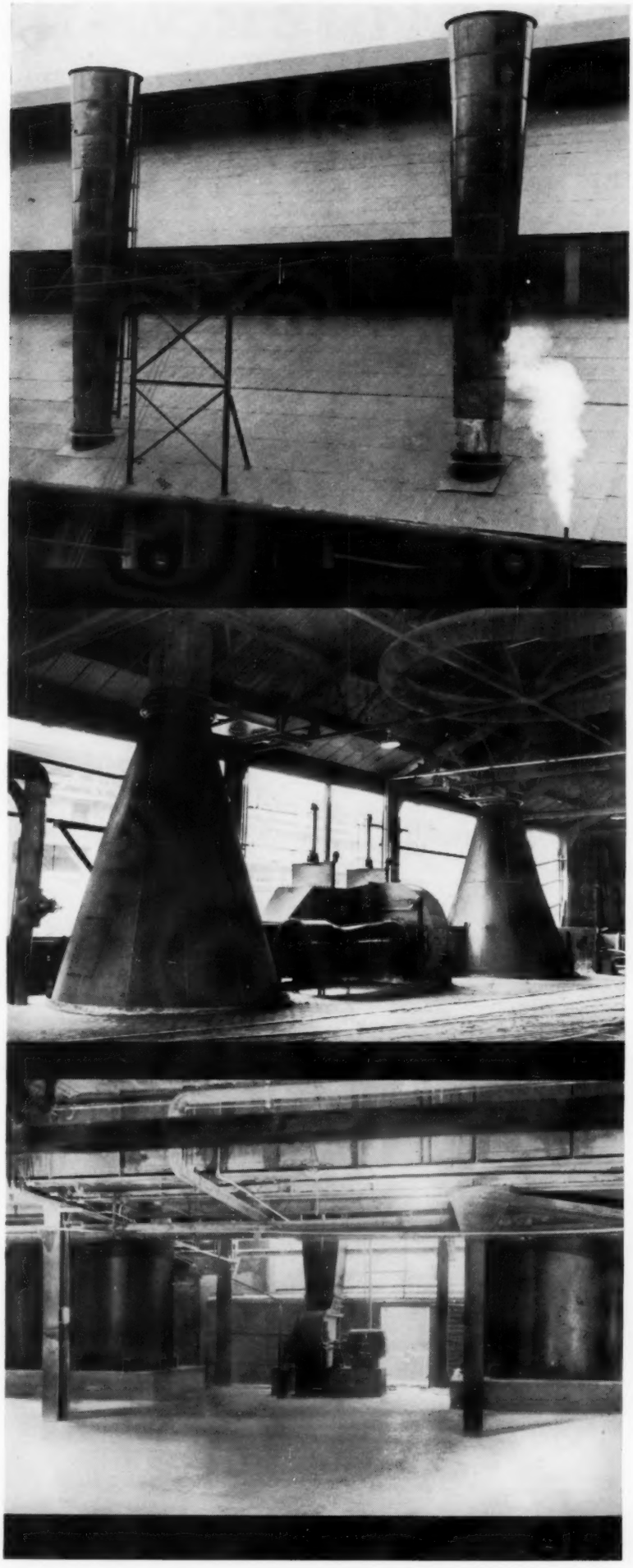

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COMBUSTION CONTROLS

The installation pictured to the left is in operation at the National Steel Corp., Weirton Steel Company Division plant in Weirton, West Virginia. The Morgan-Isley Combustion Control System affords the Weirton Steel Company a method of efficiently supplying combustion air and exhausting combustion waste products. The system provides additional checker capacity which returns more heat. It increases production because it produces faster heating.

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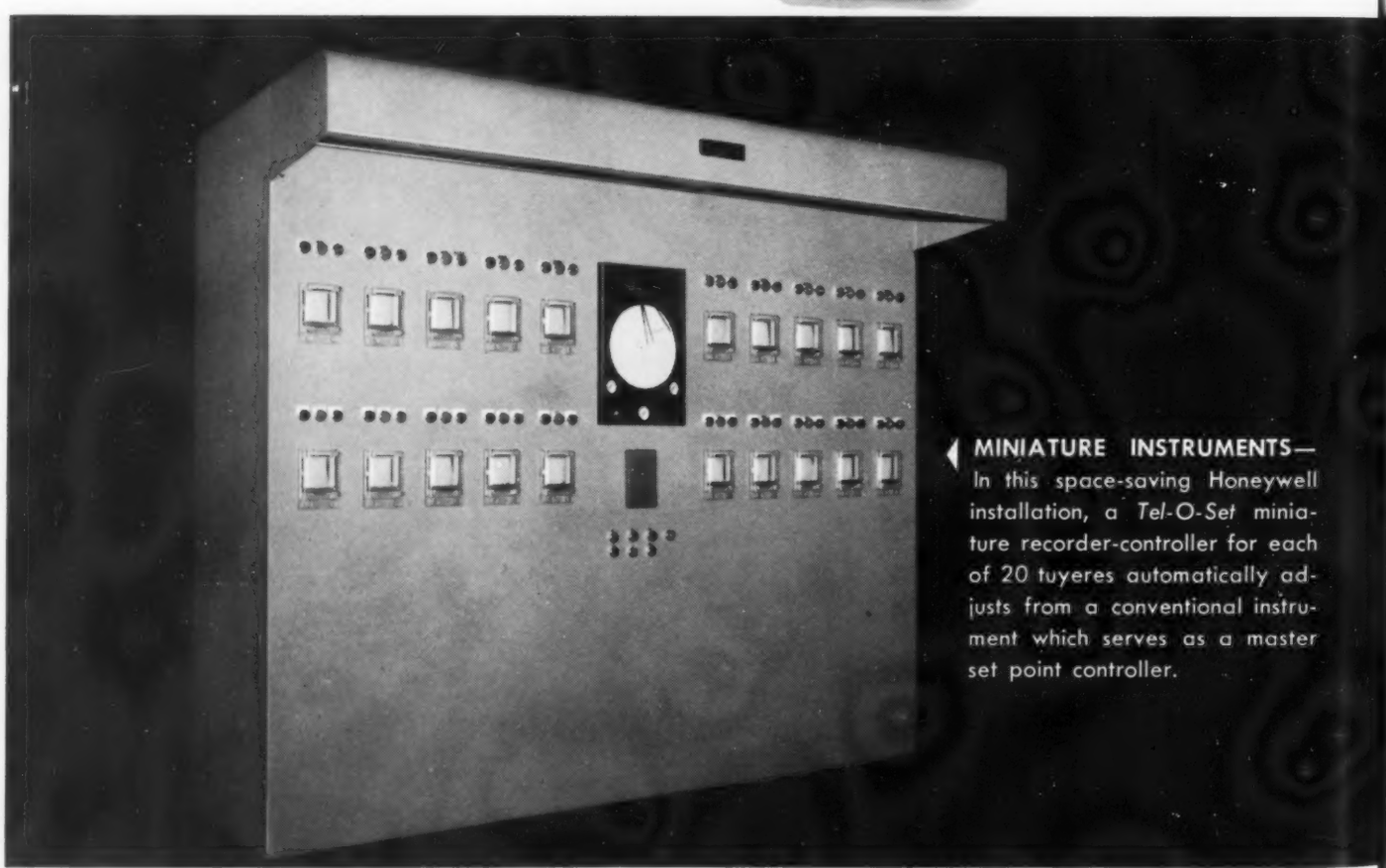


MINIATURE INSTRUMENTS— In this space-saving Honeywell installation, a *Tel-O-Set* miniature recorder-controller for each of 20 tuyeres automatically adjusts from a conventional instrument which serves as a master set point controller.

...with an automatic tuyere control system by Honeywell

Equalized control of tuyere flow helps give you better blast furnace stability. Honeywell instrumentation gives you that control . . . automatically, accurately, dependably.

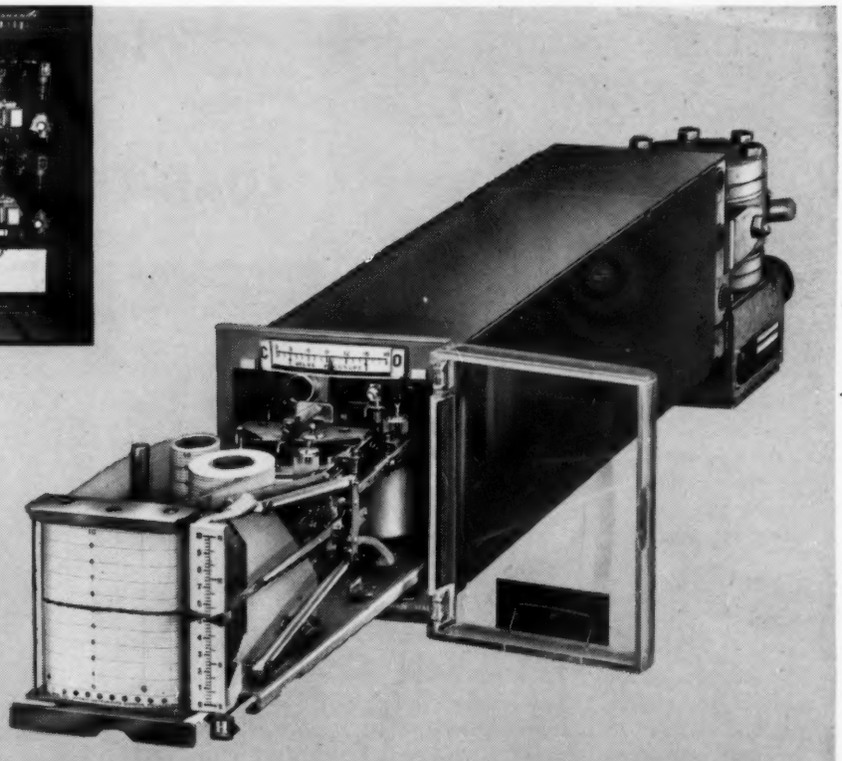
Honeywell control systems, custom-designed for your mill, proportion flow equally through each blast furnace tuyere to maintain uniform air distribution within the furnace. This stability gives you the economy that comes with efficient operation.

Each tuyere is controlled by a *Differential Converter* flow transmitter, a flow controller, valve and valve positioner. A master controller determines the correct set point and automatically adjusts each tuyere to the setting. Pressure loss is minimized because the system keeps valves open at the maximum allowable position for a given flow. After checks or casts, the master controller quickly recalculates the set point and maintains equal flow through all tuyeres, despite irregular resistance. Lags and dangerous pressure build-ups are eliminated.

Ask your nearby Honeywell field engineer for details on automatic tuyere control systems, or any steel mill instrumentation. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Phila. 44, Pa.

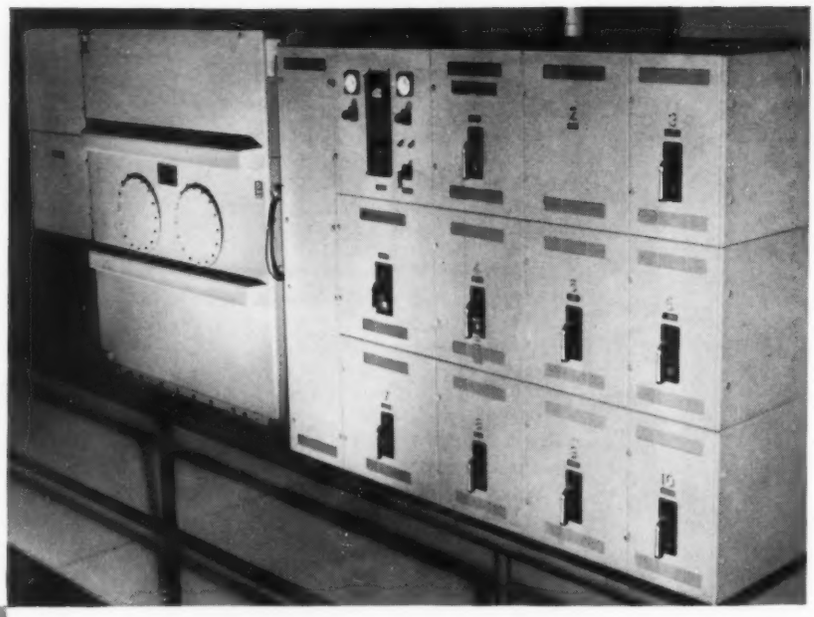
BACK-OF-PANEL VIEW gives some indication of the careful engineering that characterizes Honeywell control systems. Each panel is custom-designed to meet the requirements of a particular mill.



TEL-O-SET individual tuyere flow recorder-controller simultaneously records tuyere flow and valve position and also indicates master set point.

Honeywell

HONEYWELL *First in Control*



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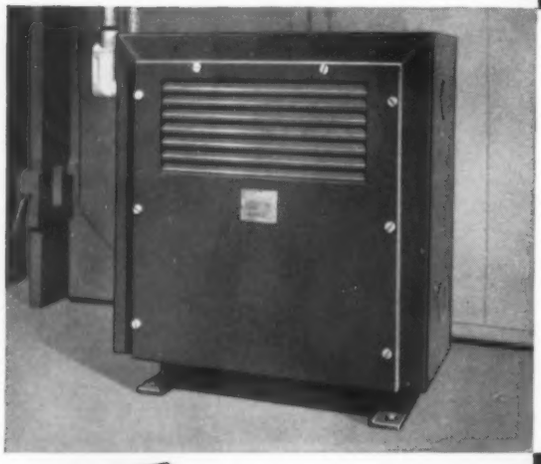

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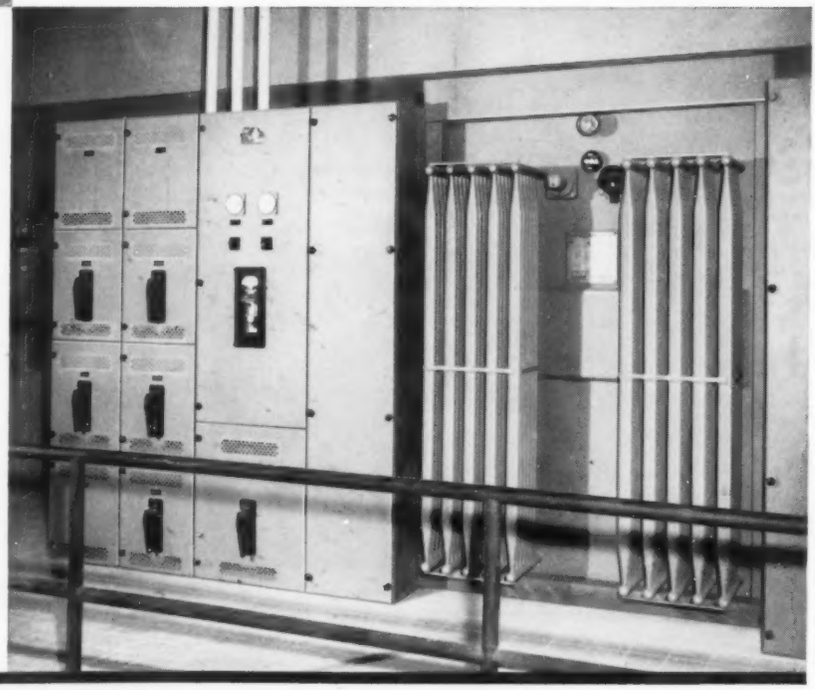

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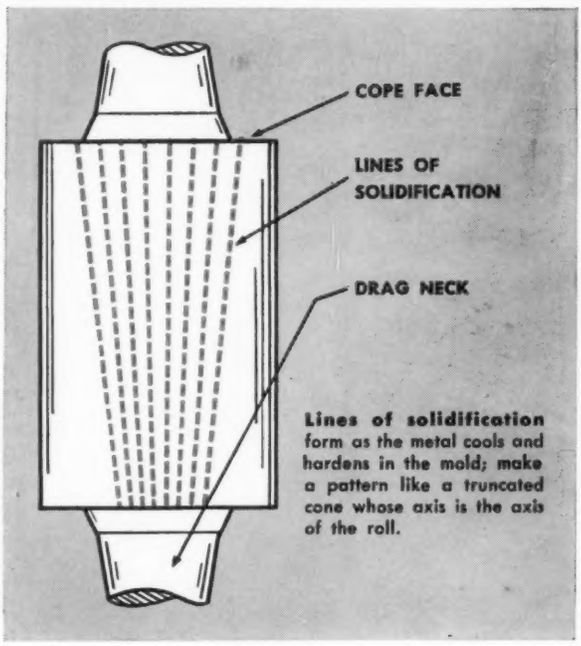
What we learn from "fingerprinting" a back-up roll


COPE FACE
LINES OF SOLIDIFICATION
DRAG NECK
Lines of solidification form as the metal cools and hardens in the mold; make a pattern like a truncated cone whose axis is the axis of the roll.

"Cope face spot depth" sounds a little mysterious, but actually it is a relatively simple, accurate guide to the future performance of back-up rolls in 4-high mills. Even more important, when the roll maker keeps sulfur print records of the spot depth on every back-up roll he ships, it is possible to relate the pattern of the print to the actual tonnage turned out by the roll, as reported by the customer. With this information at hand, Mack-Hemp metallurgists can modify the alloy "mix" or the foundry practice so that the next set of back-up rolls will give even better service.

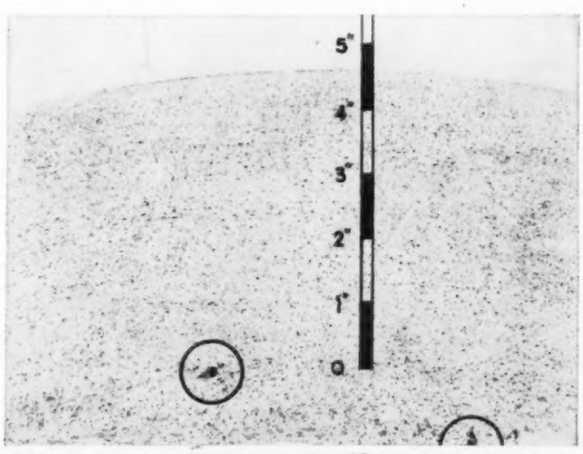
What "cope face spot depth" reveals—As a freshly-poured Mack-Hemp "Technalloy" or "Midland Superalloy" steel back-up roll cools and hardens, so-called "lines of solidification" form below the surface of the roll (see diagram). These lines arrange themselves in a cone-shaped pattern spreading outward as they ascend from the "drag" wabbler toward the upper shoulder of the roll body, or "cope face." The points where the lines of solidification end in the cope face can be detected by an acid etch, and a permanent record made by laying special photographic paper over the etched area.

As you can see, the depth of this zone of dense metal is shallowest at the cope face because of the way the lines angle outward. Hence, cope face spot depth provides a measure of the minimum amount of sound, homogeneous metal between these lines of solidification and the work surface of the roll.

Spots should be deep—In general, the roll maker's objective is to keep the spots on the cope face as deep as possible below the worn-out circumference of the roll. However, sheer depth is not the only indication of the roll's life expectancy and behavior in service. The arrangement and density of the spots also tell their story to the trained metallurgist, particularly when he studies them in the light of performance data from the customer and foundry practice at Mack-Hemp.

* * *

You can see why it's a good idea to keep careful records of tonnages rolled by your Mack-Hemp hot and cold mill back-up rolls. It's a good idea, too, to consult Mack-Hemp on any and all your problems of roll use and selection whenever they arise. Feel free to call or write us at any time.



Sulfur print of "Superalloy" back-up roll. Two spots are clearly evident at the bottom of the print (⅓ actual size).

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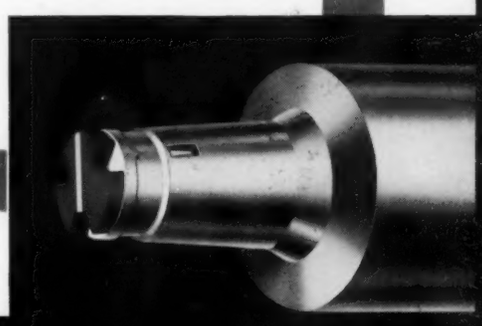
You get more tonnage from the rolls with the Striped Red Wabblers

Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery



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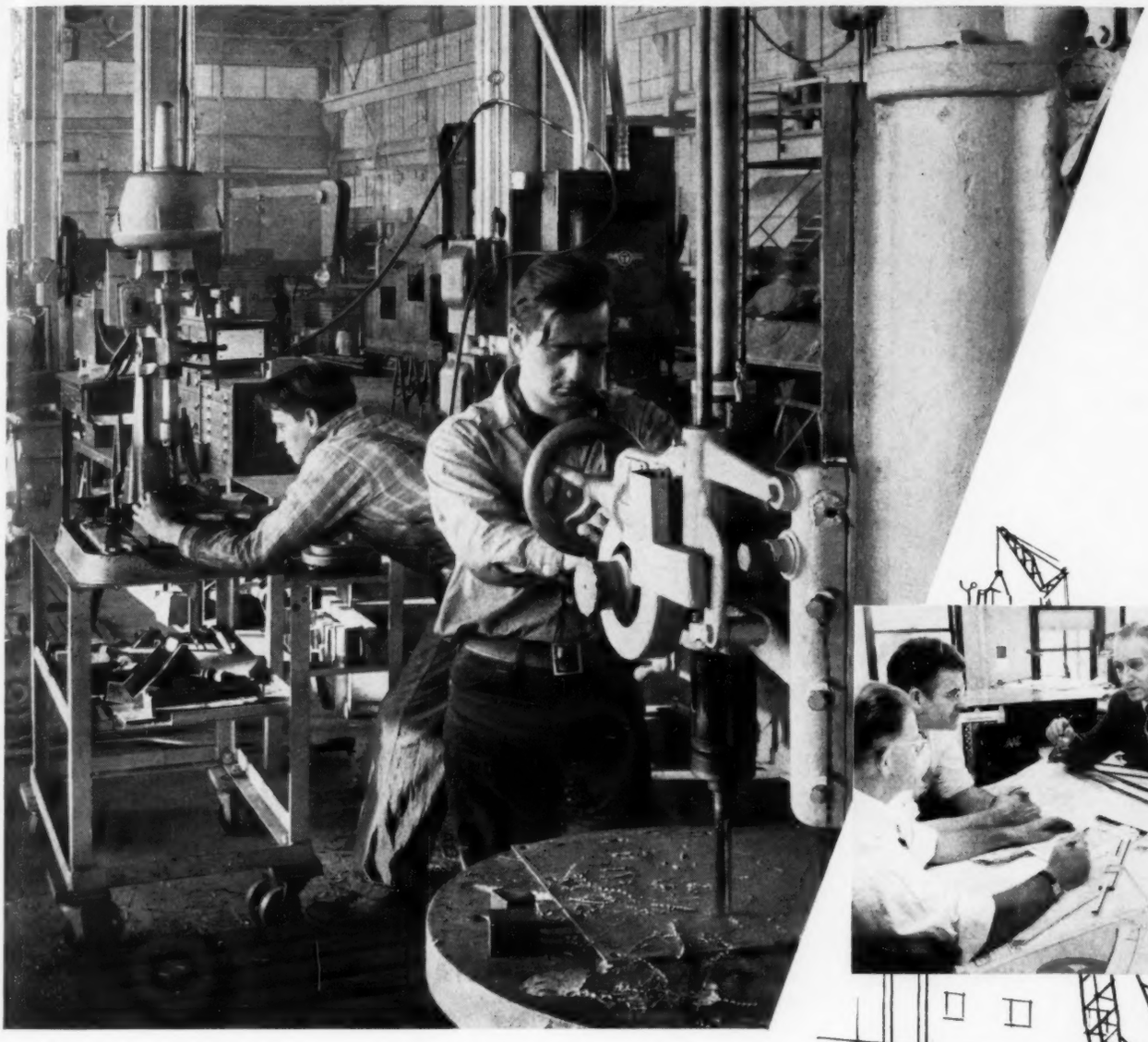

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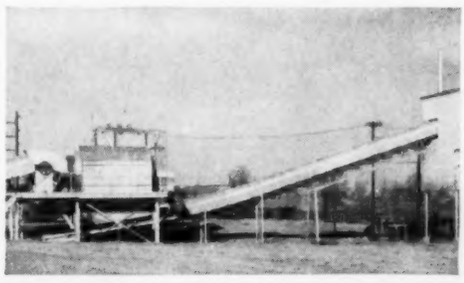

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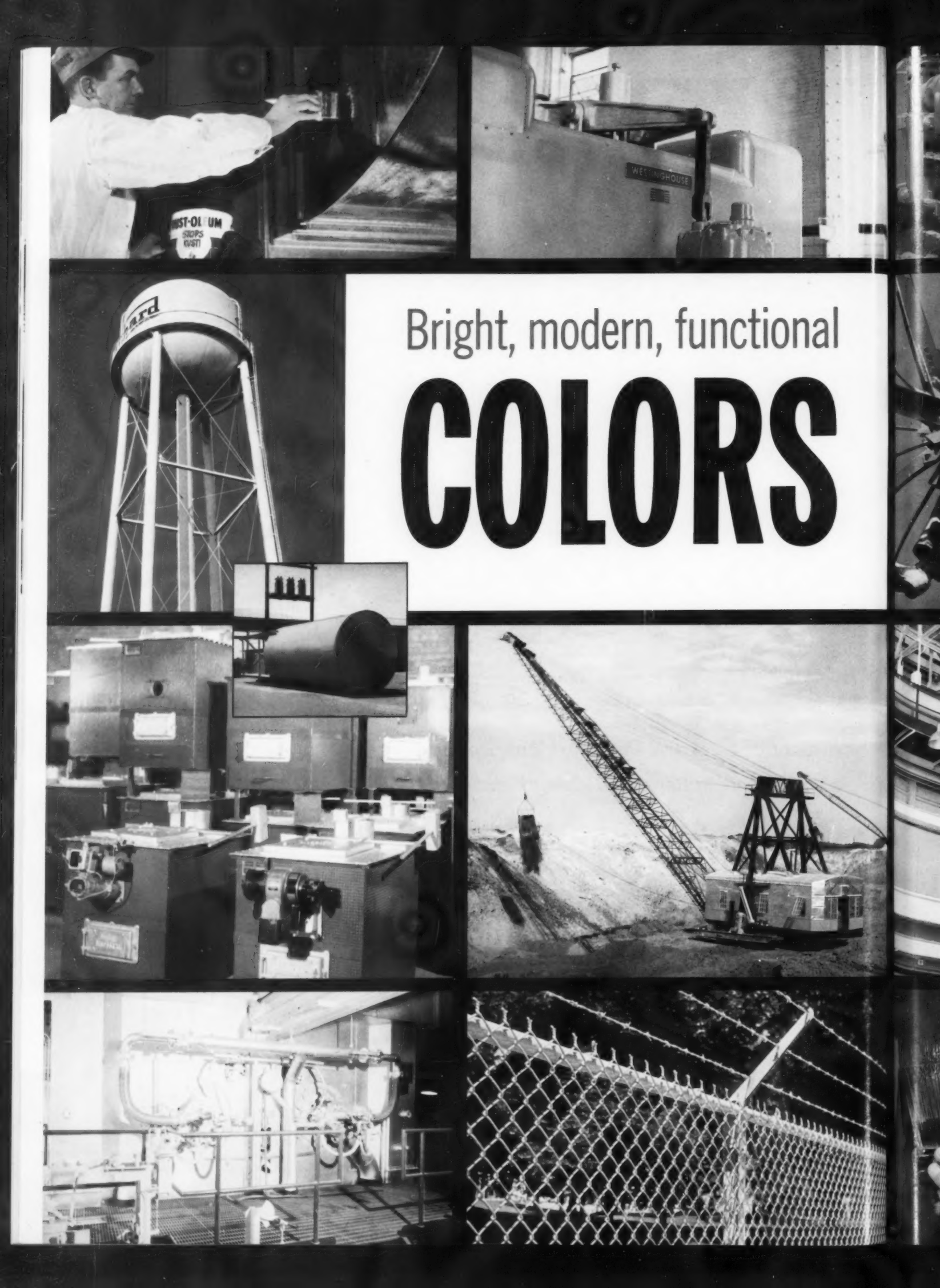

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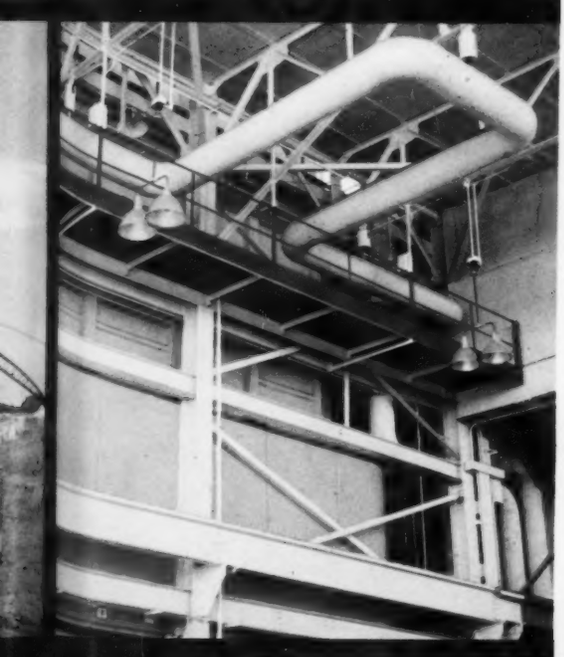

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- ☐ Complete literature with applications and color charts.
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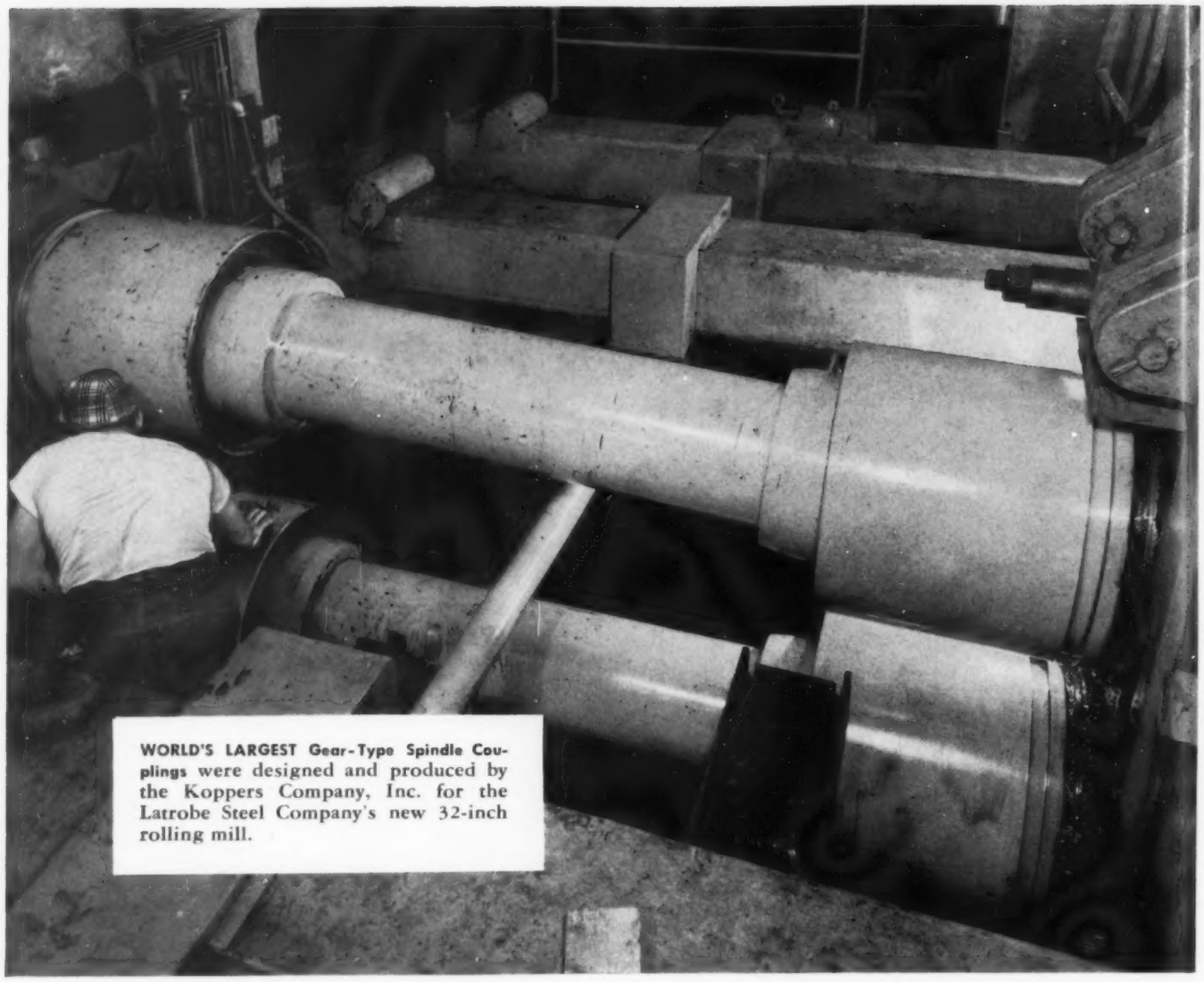

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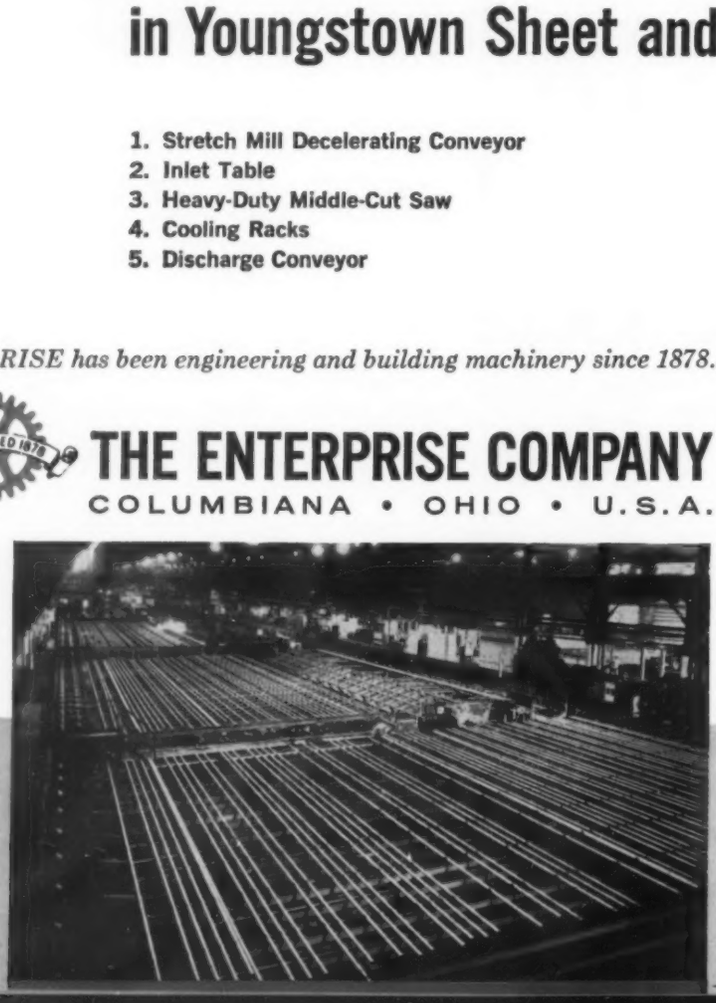

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Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"IMPROVED HEAT TREATING PRACTICE FOR COLD ROLL SLEEVES"

by I. E. BRAININ, A. I. KONDRASHOV, and V. A. KHARCHENKO. (Translation No. 4283 from Metallovedenie I Obrabotka Metallov, July, 1958)

Δ IN 1949, the Novo-Kramator plant started making sleeves for cold mill rolls of steel (0.90 per cent carbon, 0.65 per cent chromium, 0.22 per cent vanadium), melted in a basic open-hearth furnace with the usual deoxidizing practice.

It was found that maximum hardness (613 Vickers units) is obtained after quenching from 1470 to 1560 F; increase of quenching temperature to 1740 F leads to solution of all carbides, overheating and lowering of the hardness. The hardness needed for sleeves (60 to 80 Shore units) is obtained by a subsequent tempering at 610–790 F.

The sleeves are forged from ingots weighing about 30 net tons. Initial forging temperature is 2110 to 2150 F and final temperature 1470 to 1650 F. The forgings have a final outside diameter of 51 in., an inside diameter of 27½ in., and a length of 80 in.

The first batch of sleeves was forged in a single upsetting operation. However, the steel proved coarse-grained, presenting a columnar primary structure. Hence, a second upsetting step was introduced together with process annealing, between the two. The heat-treating cycle now includes an intermediate anneal between the first and second upsettings, annealing after forging, quenching and tempering to the specification hardness (60 to 75 and 70 to 85 degrees Shore).

SUMMARY

1. Appreciable grain growth and overheating of the steel starts above 1740 F, when secondary carbides are dissolved in austenite.

2. Increasing the austenitizing temperature from 1525 to 1760 F improves the stability of the retained austenite, increases the temperature of its minimum stability in the pearlite range and lowers the martensite point.

3. Forging sleeves for backing-up rolls for cold rolling with two upsetting steps renders the primary grain finer and improves the as-cast structure.

4. A two-stage isothermal treatment cycle has been worked out which does away with the need for normalizing to eliminate flakes and carbide lines, and imparts to the sleeves satisfactory hardness while leaving them quite easy to machine.

5. The quenching (water and oil) and tempering practice worked out insures the necessary surface hardness on the rolls and the least possible residual stresses.

"REPAIR OF LARGE BELL OF A BLAST FURNACE"

by V. A. KARASIK, Design Engineer, Blast Furnace Dept., Cherepovets Metallurgical Works. (Translation No. 4333 from Metallurg, May 1957, No. 5, pages 8–9)

Δ THE charging apparatuses of the blast furnaces of the Cherepovets Plant work on gas pressures of 14.7 to 16.9 psig. Blast furnace No. 2 started operation in April, 1956. The charging apparatus, which works on high top pressure does not differ from any of this kind in the Soviet Union, designed for pressurized furnace operation.

Within seven months after start of the run, the furnace began leaking gas between hopper and bell. It was clear after stoppage of the furnace that the layers of hard facing had crumbled and that destruction of the body of the bell itself had started. On the hopper there was no particular damage noticeable. It was decided to repair the damage through build-up welding.

Instead of using long electrodes manipulated through the manholes of the gas seal, the furnace was stopped and filled with granulated slag up to the level of the top wearing plates. The large bell was lowered to its bottom position and

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the manholes of the offtakes were opened. Repair workers in gasproof, fireproof hoselike equipment were lowered to the large bell.

The filling operation was applied in two layers, the first layer with low carbon steel electrodes and, after cleaning, the second layer with chromium-alloyed electrodes.

The deposited layer was cleaned, using manual electric grinding machines.

When gaging the fit of hopper and bell, the clearance at some places was as much as $\frac{1}{16}$ in. so the bell was lowered again and additional facing applied for better contact.

The job was done within 20 hr, whereas replacement of the large bell would have taken at last 60 hr. Four months of continuous operation proved that the repair job was fully satisfactory.

"PRODUCTION OF FLUXED SINTER AND ITS USE"

by A. P. YAKOBSON, Magnitogorsk Metallurgical Combine. (Translation No. 4384 from Stal', vol. 15, 1955, No. 1)

△ EXPERIMENTAL work on fluxed sinter has been carried on at various Russian plants since 1936, but trouble was experienced because of low mechanical strength and variable composition of the sinters.

In 1952, sinter plant No. 1 at Magnitogorsk began the production of fluxed sinter. Initially sinter with a basicity of 0.6 to 0.7 was produced, later raised to 0.85, and in March, 1954, to 1.2. The charge consisted of many components, but there was little difficulty in producing fluxed sinter.

With coarse crushing of the limestone, increase in basicity to 1.0 impaired sinter strength. But when ores whose basicity ranged from 0.5 to 0.7 were sintered, a sinter of good strength and basicity 1.0 and higher was produced; however, gas permeability of the bed was impaired and the quantity of return fines reduced.

The ferrous oxide content of fluxed sinter was lower than that of ordinary sinter, and 90 to 99 per cent of the sulphur was burned out in sintering. Fluxed sinter was more reducible than ordinary sinter.

The optimum basicity in fluxed sinter for each type of ore is determined experimentally; to produce high basicity, easily-reduced and strong sinters, fineness of ore and flux is essential. When the limestone is finely ground, under the conditions prevailing at Magnitogorsk, an easily reduced strong sinter with a basicity of 1.2 is produced, and it is even possible to produce on the industrial scale a strong sinter with a basicity of 3.0 and higher, which can be successfully used in blast furnaces as a flux for the complete elimination of limestone from the burdens.

The technique of producing fluxed sinter which has been developed produces a sinter with good metallurgical properties, in particular a 4 to 5 per cent higher reducibility than ordinary, and a comparatively small content of fines.

Use of fluxed sinter in blast furnaces substantially improves their performance. When up to 90 per cent of the sinter used in the furnace is fluxed, with a basicity of 0.85 to 0.90, the throughput of the furnace is 8.6 per cent higher and its coke consumption 6.4 per cent lower.

To produce fluxed sinter with high metallurgical properties, the limestone must be finely ground (preferably in hammer mills).

Introduction of $-\frac{1}{8}$-in. (about $6\frac{1}{2}$ U. S. mesh) limestone into sinter charges improves agglomeration, which increases the vertical sintering rate and the specific throughput of sintering machine 7 to 8 per cent with only a slight increase in fuel consumption.

Introduction of limestone into sinter charges containing 1.5 to 2.4 per cent sulphur does not obstruct burning out of the sulphur.

In the production of fluxed sinter, limestone and dolomite fines free from silica and alumina, and also low-strength limestone and dolomite can be used.

"BLAST FURNACE PERFORMANCE IMPROVED BY CHANGING THE BLAST COMPOSITION"

by E. M. LIKSHIN and YU. S. BORISOV, Urals Institute for Ferrous Metallurgy. (Translation No. 4403 from Stal', vol. 18, 1958, No. 5)

△ AMONG means for raising output and improving general performance of blast furnaces, change of blast composition is still not sufficiently exploited. Humidification of the blast has a limited application and with improvement of the quality of the raw materials and of operating technique it serves mainly as a means of routine control of the thermal state of the furnace and for conditioning the blast.

Oxygen enrichment of the blast (above 23 to 24 per cent) in producing conversion pig iron does not give good results because of interference with heat exchange and other processes within the furnace.

Further increase in furnace throughput can be attained by partial or complete replacement of the nitrogen in the blast by active reducing agents.

The selection of the best form of "combined" blast is made difficult because of the absence of any scientific information about the possible changes in the course of the diverse processes which occur in blast furnaces when a changeover is made to blast of a new composition. To find out the scope for, the desirability and the approximate economic value of various forms of combined blast, and the proper conditions for their practical use, a new method of calculating the characteristics of blast furnace operation has been worked out, based on a compilation of heat balances in the various zones of a furnace.

Calculations have been made for blast containing coke-oven, natural, producer, blast furnace gases, carbon dioxide, fuel oil and steam heated to various temperatures and present in various proportions in the blast. Two methods of using pulverized coal fuel were also studied.

Calculations indicate that all additions to an air blast can be divided into:

1. Those which absorb heat in the tuyere zone (steam, carbon dioxide, blast furnace gas).
2. Those which liberate heat in the same zone (coke-oven and natural gases, fuel oil, etc).
3. Those which neither liberate nor absorb heat in this zone (producer gas, etc.).

All additions lower the combustion temperature in front of the tuyeres. Those of groups (2) and (3) decrease the rate of combustion of coke in front of the tuyeres. These drawbacks can all be overcome by oxygen enrichment of the blast.

SUMMARY

1. For the successful use of all

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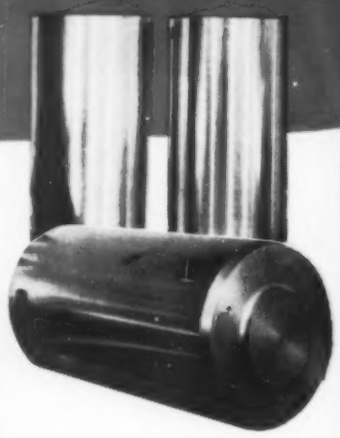

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forms of combined blast, the blast must be simultaneously oxygen-enriched.

2. Calculations show that enrichment of blast with fuel oil, natural, coke-oven and producer gases, and also the injection of pulverized coal directly into the furnace or as a gas produced in cyclone-type producers should act extremely effectively on the blast furnace process; with the gases considered, a maximum 30 to 35 per cent reduction in specific coke consumption and a 40 per cent increase in furnace output can be expected, with simultaneous increase in calorific value of the blast furnace gas.

3. There seems little scope for injecting steam or carbon dioxide into the blast.

4. Increase of temperature of the components of a combined blast should improve furnace performance, as does heating of ordinary blast.

5. Blast "enrichers" should be injected into the tuyere zone.

6. The method of calculation worked out makes it possible to approximate the effect of various forms of combined blast, and indicates that it is desirable very soon to carry out semi-industrial or industrial tests on combined blast.

OTHER AVAILABLE TRANSLATIONS

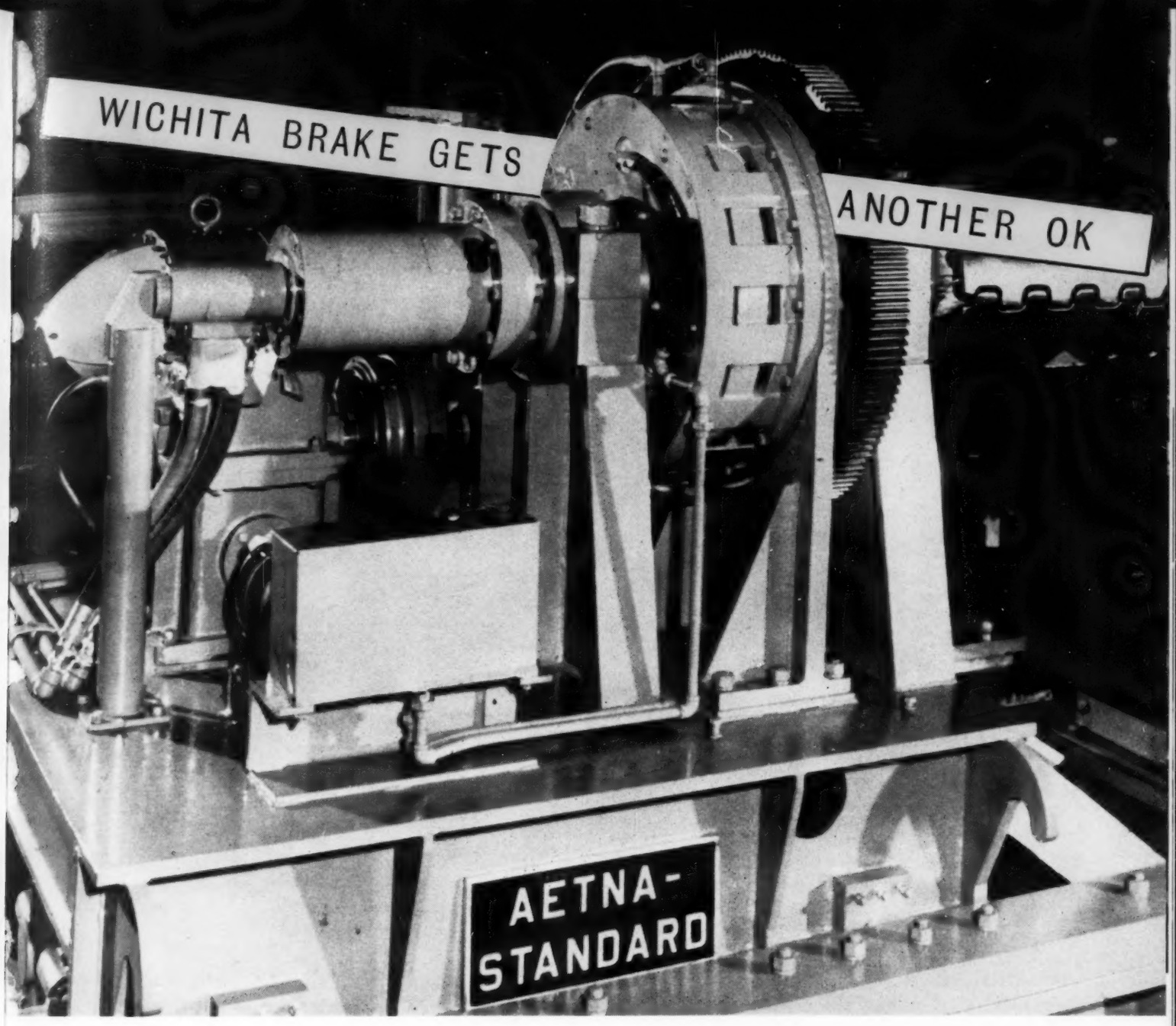
"Effect of Ingot Weight upon Quality of Structural Steels," M. I. Kolosov et al Stal', vol. 18, 1958, No. 5, Exploration of possibilities of casting some steels into 5-ton ingots, instead of 3 and 1.3-ton weights, to increase pouring-bay and blooming-mill production. Steel compositions studied; (a) 0.14–0.21 C, 1.35–1.65 Cr, 4–4.5 Ni, 0.80–1.20 W; (b) 0.36–0.44 C, 0.60–0.90 Cr, 1.25–3.75 Ni, 0.20–0.30 Mo; (c) 0.11–0.17 C, 1.25–1.75 Cr, 3.25–3.75 Ni; (d) 0.27–0.34 C, 1.00–1.30 Mn, 0.90–1.20 Si, 0.90–1.20 Cr, 1.40–1.80 Ni, all with extra low P and S contents. Investigational procedure. Macrostructure and mechanical properties of ingots and blooms rolled from the various-size ingots. Steels of which ingot size can be increased to 5 tons without detriment to steel quality. (Translation No. 4453).

"Bright Quenching of Steel," A. K. Beskrovnyi. Metallovedenie I Obrabotka Metallov, October, 1958. Setup for simultaneous quenching and electropolishing, called "bright quenching" of steel parts. Composition of electrolyte. Best current density and immersion time for various carbon steels (0.20 to 1.25 per cent C). Effect of electrolyte temperature on hardness. Role of nascent hydrogen in quench cracking. Advantages of proposed bright quenching technique: elimination of surface defects; absence of quench cracks; direct deposition of Cr, Ni, etc., on bright quenched steel. (Translation No. 4398)

"Heating Power of Nitrate Baths," P. Ya. Yakovlev. Metallovedenie I Obrabotka Metallov, October, 1958. No. 10. Investigation of ways and means of preventing impairment of the heating capacity of heat-treating baths of fused salts, and of regenerating such baths. Relative merits of sodium, potassium, barium, and calcium chlorides, hydroxides, and anhydrous barium nitrate. Operating temperatures of saltpeter baths at which sodium nitride additions are desirable. Rational selection of composition of nitrate baths. Bath temperatures at which deviations from the eutectic composition are permissible. Frequency of sludge removal. (Translation No. 4396)

"Forging Practice and Quality of Steel for Steam-Turbine and Turbogenerator Rotors," N. V. Tikhomirov. Metalloved I Obrabotka Metallov, April, 1958. No. 4. Report on production of all-forged heavy rotors. Particulars on the various forging operations. Forging technique involving cold trepanning: advantages and drawbacks. Successful forging of various steam-turbine rotors at USSR and Czechoslovak plants. Analysis of defects found in rotor steels. (Translation No. 4186)

"Processes in the Hearth of a Blast Furnace Operated at Elevated Top Pressure," B. F. Goncharov. Stal', vol. 18, 1958, No. 2. Investigation of the processes of reduction occurring in the liquid masses which form above the tuyere line, and of the changes in composition of these masses in the oxidizing zone, coupled with a determination of the composition of the gaseous phase in a pressurized blast furnace working on a burden containing 75 to 85 per cent self-fluxing sinter. (Translation No. 4229)



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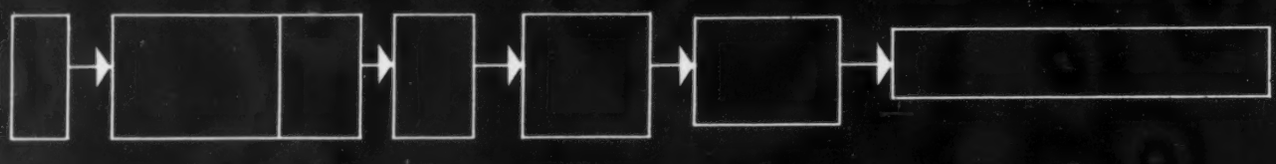

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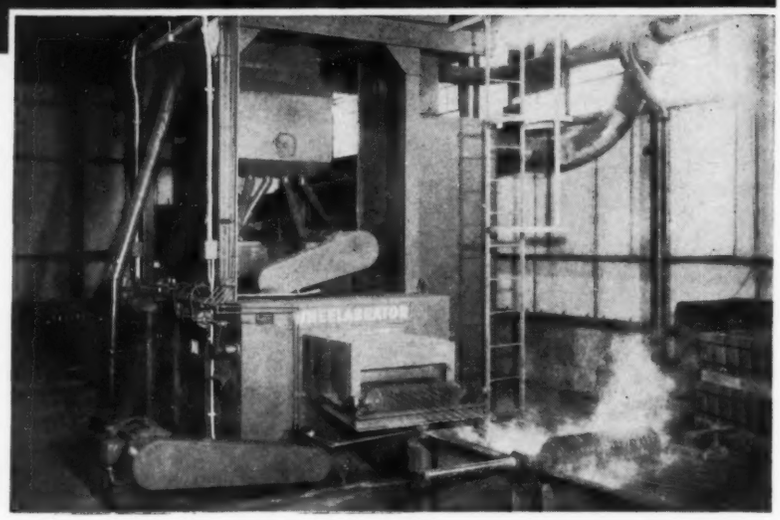

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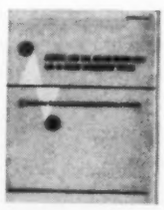

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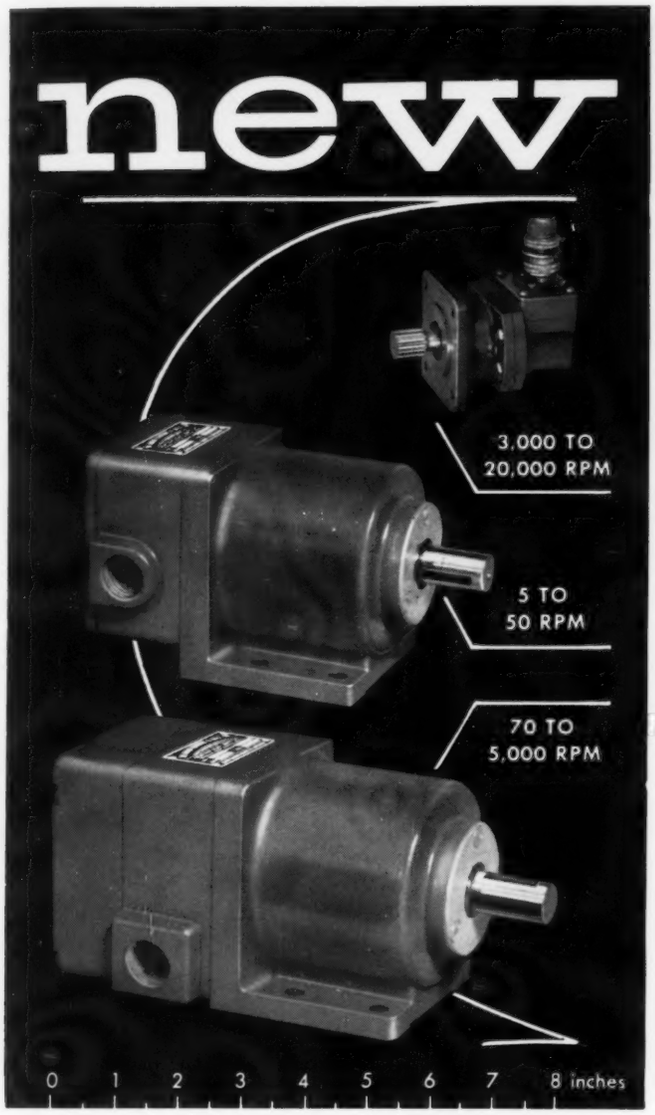

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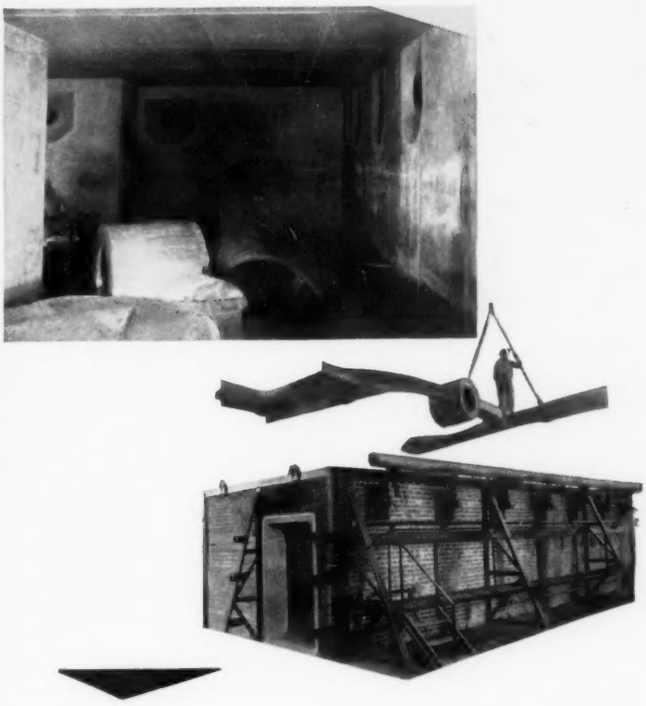
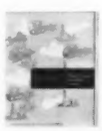
Plicast L.W.I. in large annealing furnace

. . . heats and cools faster
. . . *SPEEDS PRODUCTION*



That's what the man responsible for this 38′4″ by 23′4″ by 9′11½″ annealing furnace says of its complete one-piece Plibrico lining.

Production is expedited because Plicast L.W.I. heats rapidly and cools quickly. That's just one of its advantages. A Plicast L.W.I. lining has stamina, too, for it is stronger in hot-load compressive strength than insulating fire brick, and it's structurally stronger since it is monolithic, all one piece as the photo shows.



See how Plibrico refractories speed production and reduce maintenance costs for industrial, foundry and steel mill furnaces. Send for FREE Illustrated Catalog 69 or call your local Plibrico man.

Plibrico REFRACTORIES ENGINEERING CONSTRUCTION

PLIBRICO COMPANY 1804 Kingsbury St., Chicago 14, Ill.

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Now! Porter goes basic! The first in the south, this new basic refractories plant at Pascagoula went "on stream" **during February**

Porter's new $12 million Pascagoula Works is a sea-water periclase and basic brick facility using the finest in modern equipment in a fully integrated production unit.

Southern industry will soon begin benefiting from faster deliveries and lower freight rates on all forms of basic refractories from H. K. Porter's new Pascagoula Works on the Gulf Coast. Inland waterways, too, will allow easy access to America's industrial heartland.

Products of this new works—Porter's 15th refractories plant—will include burned, chemically bonded, plated and plain brick, mortars, castables, plastics and ramming mixes of chrome and periclase compositions. A unique double-burning process employed in producing Porter periclase grain insures basic refractory products of the highest quality.

Annual output of this new plant indicates an ample, dependable source of supply. Equally important, Porter engineers and ceramists provide the complete customer service that is rapidly becoming recognized as a Porter principle.

For information on shipments, prices, or *any* refractories problem, write *Pascagoula Works, Refractories Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pa.*

PORTER BASIC REFRACTORY PRODUCTS

BASIC REFRACTORY BRICK
(burned and chemically bonded in both metal clad and plain categories)

CM-30	Chrome Magnesite
CM-40	Chrome Magnesite (Roof Brick)
MC-70	Magnesite Chrome
Kilmag	Magnesite Chrome (for rotary kilns, offered in burned and plated only)
M-90	Periclase

BASIC REFRACTORY SPECIALTIES

Kromtite	Chrome Air-Set Mortar
Plastikrom	Plastic Chrome Ore
Kromor	Ground Chrome Ore
Kromform	Chrome Castable
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Peritite	Periclase Air-Set Mortar

REFRACTORIES DIVISION **PORTER** ***H.K. PORTER COMPANY, INC.***

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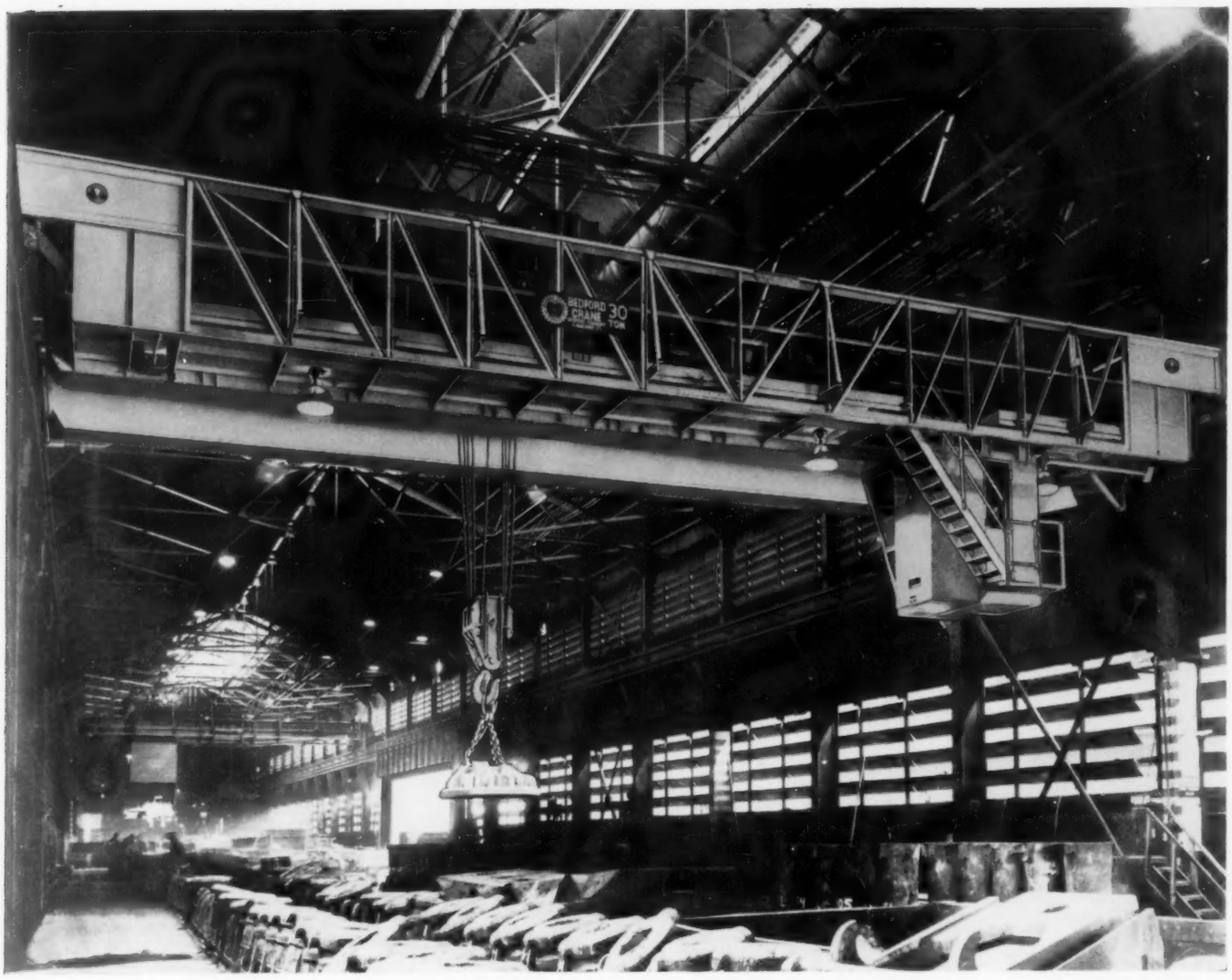

Another Bedford Mill Type Crane at Timken Roller Bearing Company

The Timken Roller Bearing Company has just installed a new 30-ton Bedford crane over the stripper building in their mill at Canton, Ohio. This is the second Bedford crane to be installed by the Timken Roller Bearing Company at Canton since July, 1952. The new crane has a 61′2″ span with 32′5″ lift. Built to AISE specifications, it has air-conditioned cab, worm drive gear on the hoist, and welded girders.

Proof of the superiority of Bedford cranes is found in the high percentage of repeat orders from important owners through the years.

Available in all types and sizes . . . from 5 tons to 350 tons, and up, for all kinds of indoor and outdoor services . . . each Bedford crane is individually engineered and precision built for its specific application.

Built to the most modern standards and backed by more than 52 years of specialized crane building and *utilization experience* . . . Bedford cranes have won fame the world over for advanced design—and for safe, smooth, more dependable performance.

You are invited to consult a Bedford engineer on your next crane problem . . . with all the facts on the table we believe you too will make your next crane a Bedford.

(Write for complete catalog describing Bedford Cranes in detail.)

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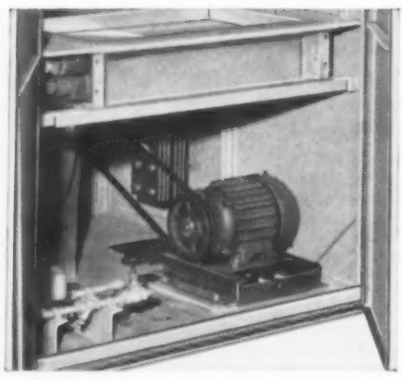

Effective cooling — closed recirculating air system features air-to-water heat exchange and delivers same amount of cooling air to each diode. Air is sealed in. Direct air cooling system also available.

Only application experience like this can give you highest conversion efficiency

High power conversion efficiency at low cost is the major advantage of the semi-conductor rectifier. But this high efficiency — as high as 95% — can be obtained only when the unit is *correctly applied*.

Allis-Chalmers 30 years of experience in developing, manufacturing and *applying* rectifiers assures you of the highest conversion efficiency. This background of experience, plus vast research and engineering facilities, is available for a thorough analysis of your requirements. Then, specific, unbiased equipment recommendations are made — dictated solely by your requirements — because Allis-Chalmers makes all types of rectifiers.

Every semi-conductor rectifier installed by Allis-Chalmers has performed to the complete satisfaction of the user. Your local A-C man can tell you how a semi-conductor rectifier can be applied profitably to your operations. Call him. Or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

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A-C ALLIS-CHALMERS **ALLIS-CHALMERS**

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America's

Best Known

LADLES..

designed

and

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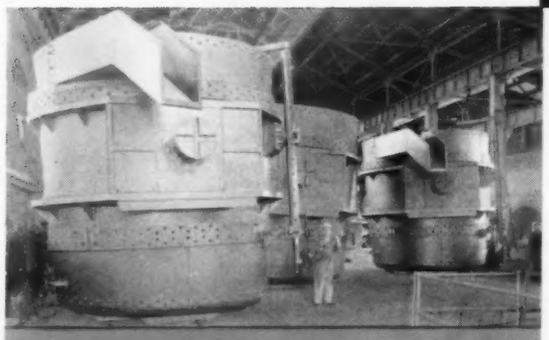
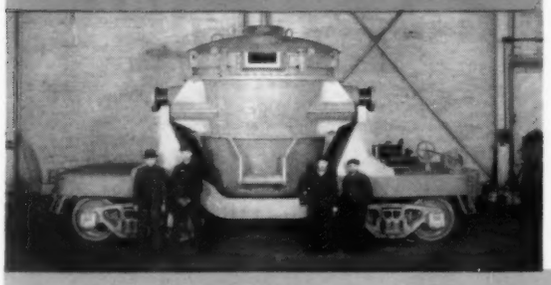
Photo courtesy Jones & Laughlin Steel Corporation, Pittsburgh, Pa.



The superior strength of PECor ladles permits many customers heavy overloads without danger, and capacities are often increased with inexpensive extension of top or bottom shell sections.

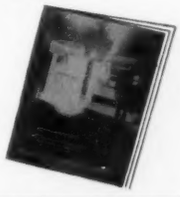


Elimination of horizontal shell plate welds adds strength and service life

Hundreds of PECor ladles—many designed and fabricated to individual specs—are in use daily in steel and other metal producing plants across the country. These range in size from 5-ton "midgets" to the largest used today. They represent many original and sound advances by PECor engineers.

Without obligation, we will be glad to consult with you about a PECor ladle built to your exact needs.

Ask about our new special design *light weight* ladles.



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Formerly, slip rings were reground every 6 to 8 weeks!
STILL GOING STRONG
STILL GOIN' STRONG
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STILL GOING STRONG
MAINTENANCE DEPARTMENT

Slip ring motor trouble ended here May 23, 1958!

(the day they switched to NATIONAL TRADE MARK Brushes)

LOUIS J. ESPOSITO

Scene: a busy mid-western ore washing plant. *Problem:* threading and grooving on slip ring motors. Two months seldom went by without an expensive regrinding job on every motor, says "National" Carbon Brush Man Louis J. Esposito.

Lou first determined the cause of the trouble by analyzing workloads and the resulting current requirements. His recommendation: "National" Brush Grade AY. *Result:* no more slip ring trouble.

Not only did a costly problem disappear, but plant management also was able to release service facilities for better maintenance elsewhere.

What about *your* brush problem? You can easily have expert help. There's a specially trained "National" Carbon Brush Man as close as your telephone. Call him today, or if you prefer, write to National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

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Reactor core supports of steel, signal bridges of aluminum . . . evidence of B-L-H scope and skill in fabrication

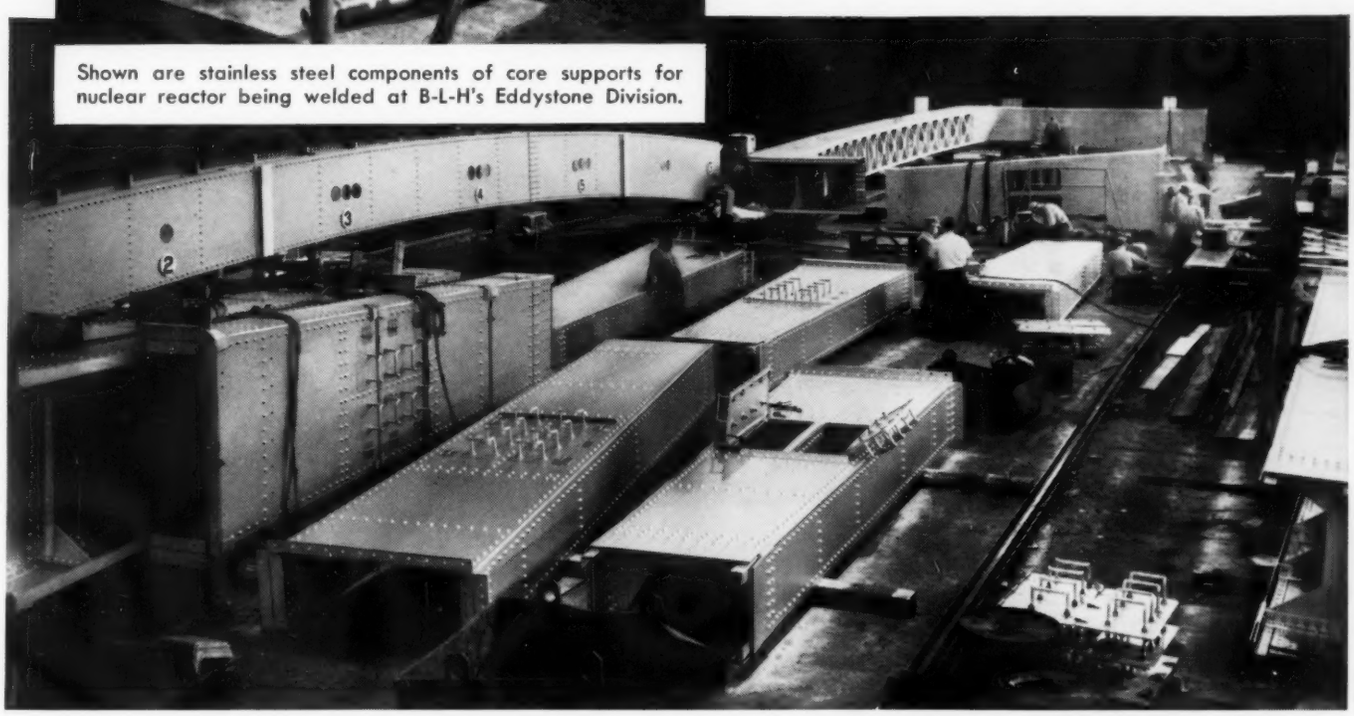
Shown are stainless steel components of core supports for nuclear reactor being welded at B-L-H's Eddystone Division.

Traffic signal bridges or nuclear reactor core supports, 100-ton pressure vessels or a hub and shaft assembly for a wind tunnel—no matter how big or unusual or complex the fabricating job, whether ferrous or nonferrous metals, B-L-H's Eddystone Division can handle it—economically, swiftly, expertly.

The signal bridges (see illustration) were constructed of structural aluminum sections, plates and bars in conformance with the strictest specifications. There are 15 of these structures, and they are 84 feet long. In Eddystone's huge shop—13 bays, each 900 ft. long—handling these giants presented no problem.

The nuclear reactor core supports, fabricated of stainless steel, called for rolling, welding, stress-relieving, and extremely accurate machining. In spite of the close tolerances required, expert planning and accurate manufacturing permitted final assembly of the core and core components with ease and a minimum of selective preassembly.

Write us for a free copy of our illustrated Weldment Bulletin 7001. It will give you an excellent idea of the broad scope of our work.



Components of traffic signal bridges for Delaware River Turnpike Bridge in vast fabricating shop at Eddystone.

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except our customers

This is of course our one-way fired soaking pit . . . fired from the top.

The location of the burner is only one of the features responsible for its enthusiastic acceptance. Most important however are the 30 years of experience and refinements which we have built into the pit since we first introduced it.

That is why, today, it is the pit everybody respects . . . especially our customers.

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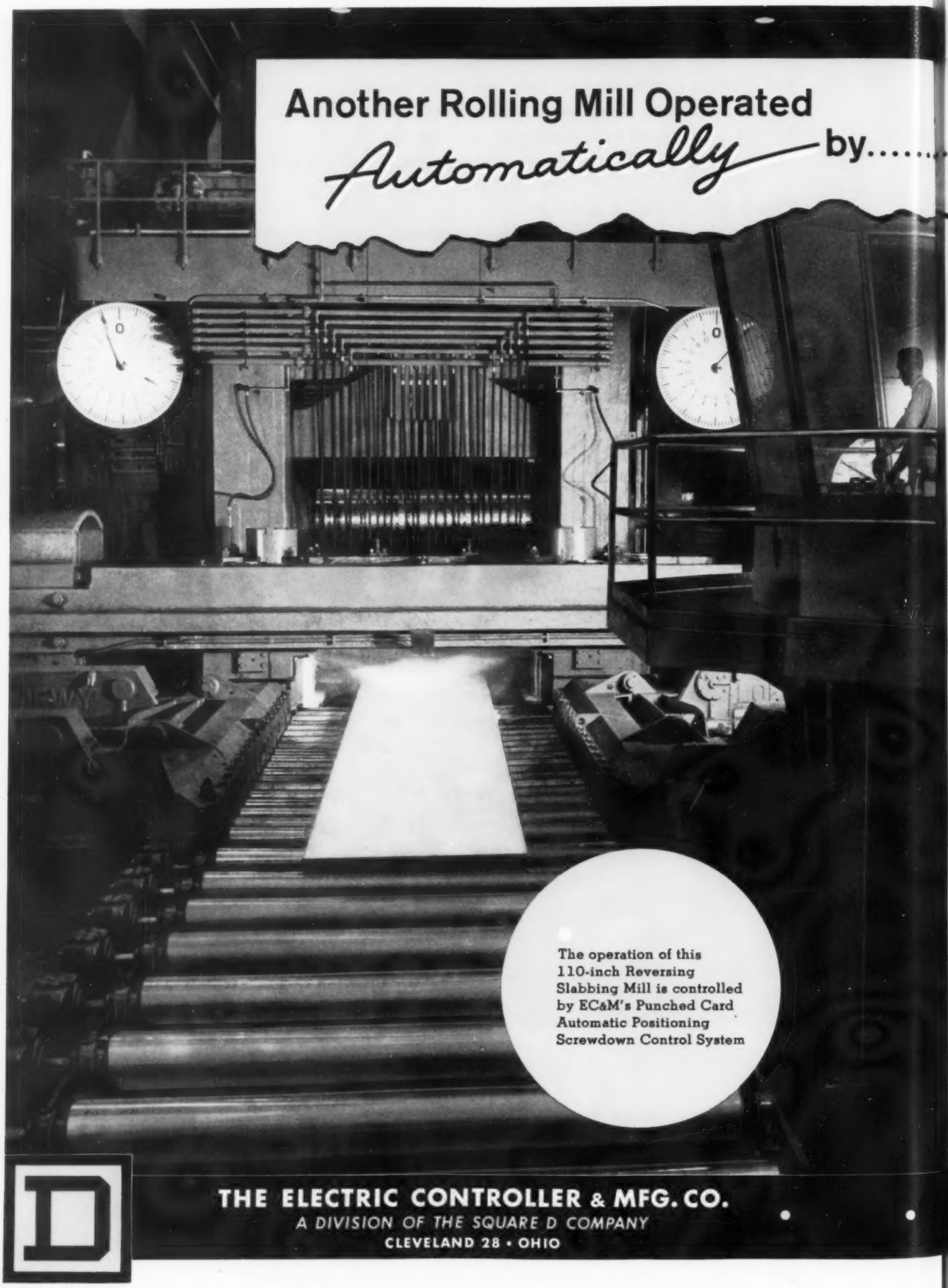
Surface


Another Rolling Mill Operated
Automatically by.....
The operation of this 110-inch Reversing Slabbing Mill is controlled by EC&M's Punched Card Automatic Positioning Screwdown Control System
THE ELECTRIC CONTROLLER & MFG. CO.
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EC&M PUNCHED CARD CONTROL

Since 1937, EC&M has been the pioneer in the development of Automatic Positioning Screwdown Control Systems. With EC&M's Punched Card System of scheduling, new operators can be quickly trained to produce greater tonnage to accurate tolerances—automatically. Since rolling is automatically maintained to specifications issued by the Metallurgical Department, the highest quality of the finished product is assured.

With EC&M's Punched Card System of automatic rolling, the operator can easily change from automatic to manual control and back again. To change schedules, a new card is inserted in the card reader. Cards can be stored and re-used when an identical rolling schedule is needed.

The EC&M Automatic Positioning Screwdown Control System can be furnished with Direct Reading Card System, IBM Card System or Slider Type Schedule Panel.

***Write** for Bulletin 6550*
for complete information

A single card containing the schedule for all passes is easily inserted in the Card Reader. With the card in place, the operator, by pressing a single pushbutton once for each pass, positions the rolls accurately. There is no schedule to memorize.

This 168-inch Reversing Roughing Mill is also equipped with EC&M's Punched Card Automatic Positioning Screwdown Control System

1794

SALEM-BROSIUS

adds two new divisions to widen its scope of service to industry

Salem-Brosius recently acquired Alloy Manufacturing Corp. of Pittsburgh and now, through that subsidiary, has purchased the R. H. Freitag Manufacturing Co. of Akron, Ohio. To those who know both companies, the benefits the new team will bring to industry are self-evident.

Atomic energy is a case in point. Alloy specializes in precision fabrication and welding of parts for nuclear reactors, while Freitag machines and finishes the same equipment . . . thus making Salem-Brosius an integrated supplier to atomic prime contractors. The added service capacity of the new combined facility also will benefit all other industries that require precision finished parts and equipment.

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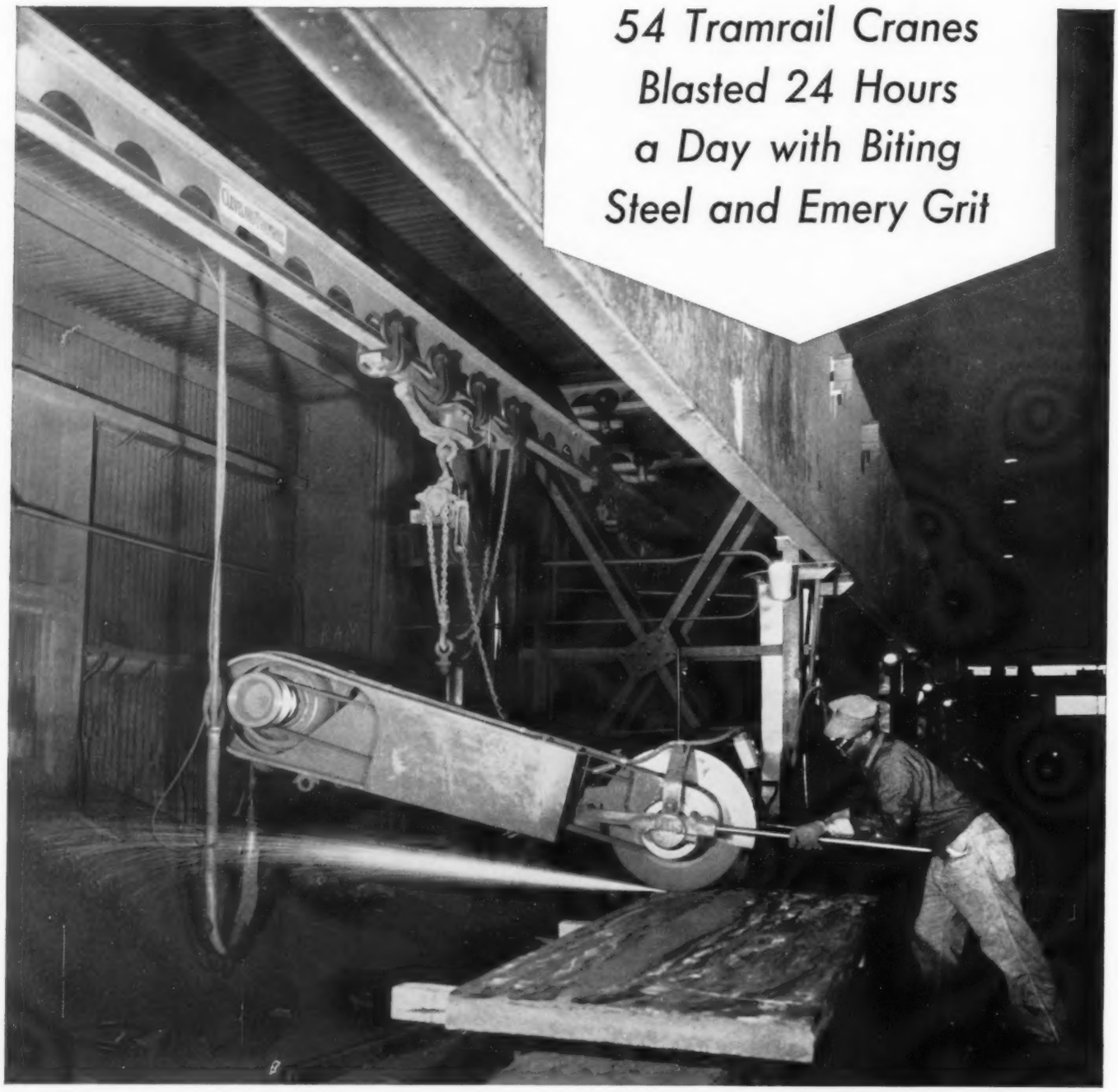

54 Tramrail Cranes Blasted 24 Hours a Day with Biting Steel and Emery Grit

FOR years Cleveland Tramrail cranes have been handling swing grinders at a large Pennsylvania steel mill.

Despite the continuous storms of fine, penetrating, corrosive dust, the cranes operate with negligible maintenance.

The design and quality of Cleveland Tramrail equipment is of importance for every job, but on the tough ones like this is where these factors quickly prove their worth.

Cleveland Tramrail cranes are particularly well suited for swing grinder operation because of their free easy movement in any direction. This permits flat grinding over a wide area and avoids "dishing" of grinder wheel into the metal. Easy crane operation greatly reduces worker fatigue.

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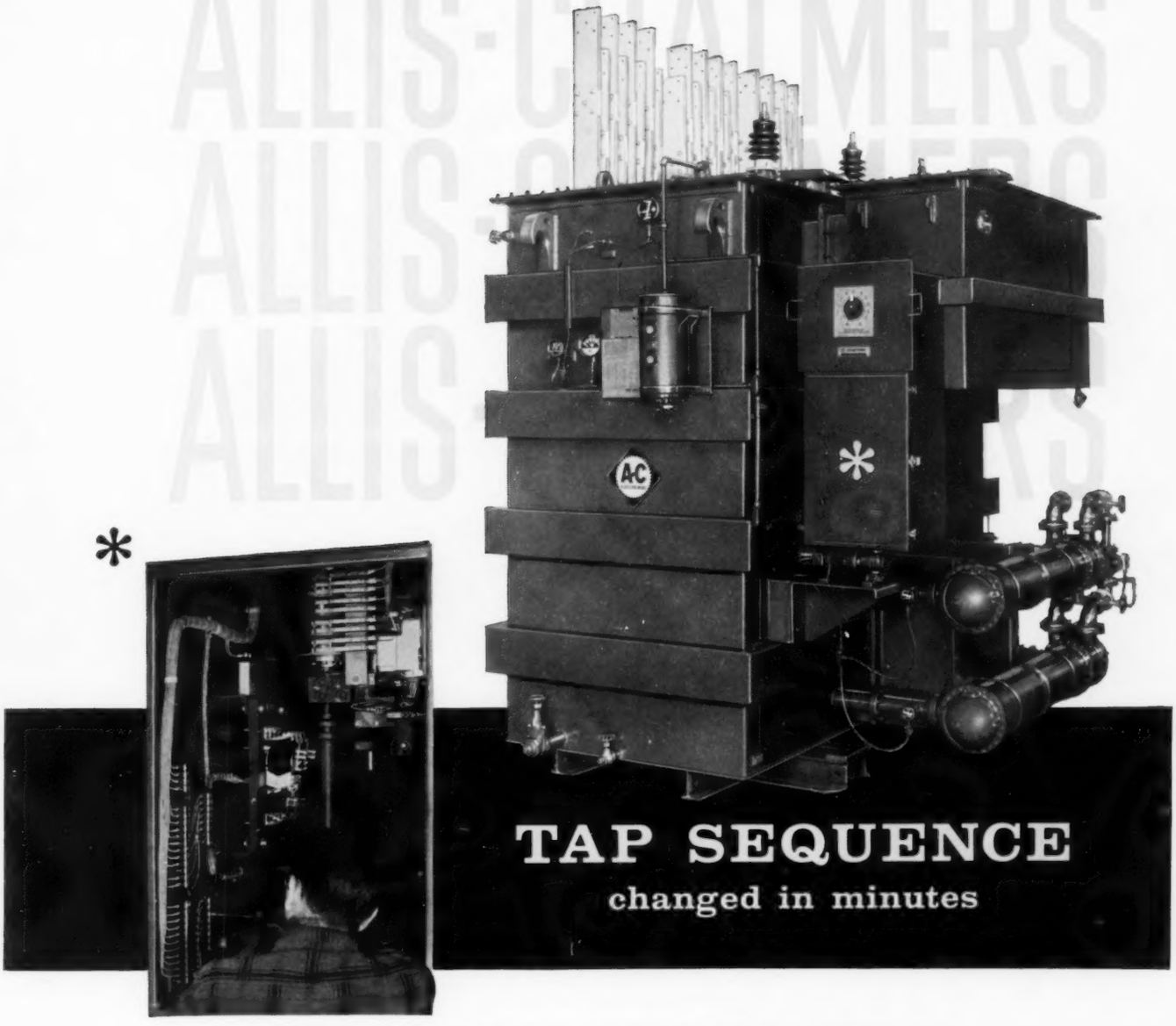


with Selectoheat Control on Allis-Chalmers Furnace Transformers

Down-time for tap sequence changes is slashed from hours to minutes with the exclusive *Selectoheat* control on Allis-Chalmers furnace transformers. Moreover, tap changes are made at eye-level to end the old hazards of working on top of the transformer.

It's Quick, Easy and Safe

Here's how it works. All primary taps are brought to a motor-operated tap changer in a separate compartment mounted on the side of the tank at eye-and-working level. Positions on the tap changer panels are connected to the *Selectoheat* control board.

Here, a series of terminals are then connected to set up the required heat sequence. Tap positions are then obtained through the motor-operated tap changer in the usual manner from the furnace operator's control panel.

Because under-oil terminal boards are eliminated, transformer height has been reduced. Still another advantage is eliminating the need for opening the main tank, except for periodic inspections.

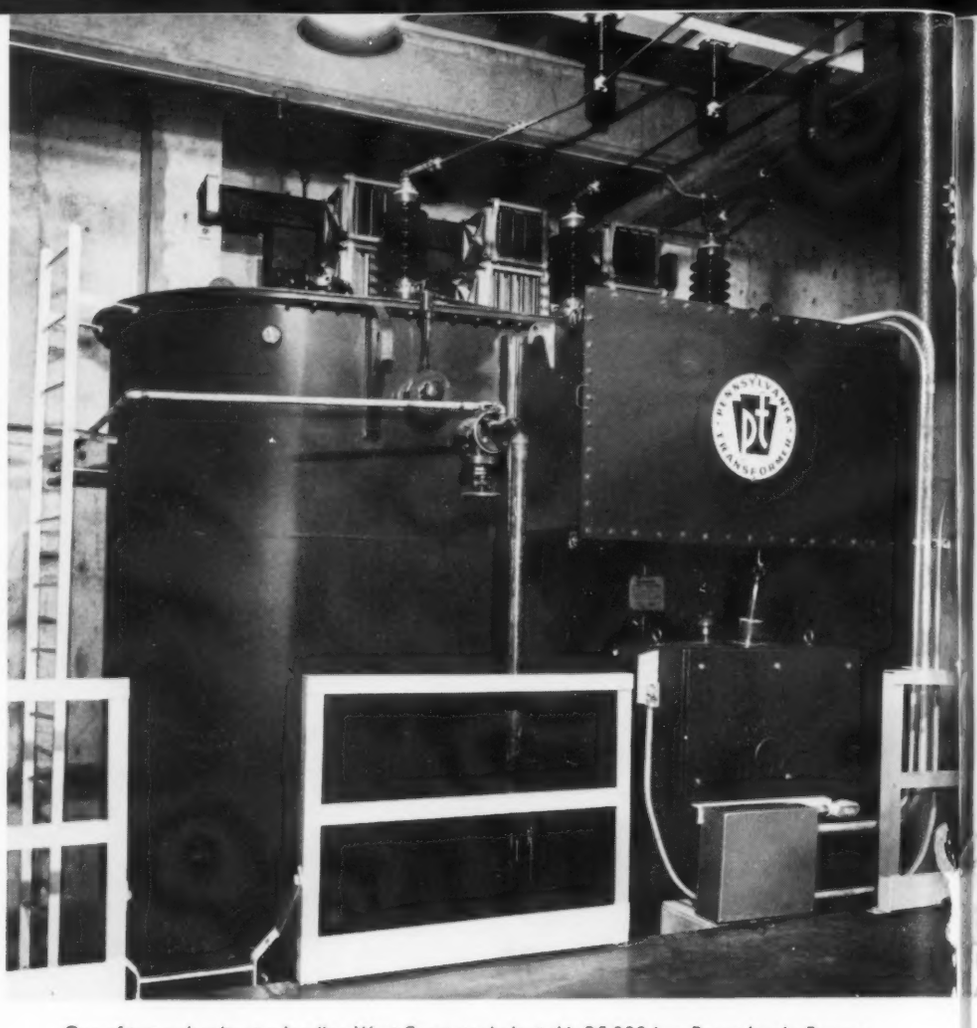
Call your A-C man for all the details. Or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

Selectoheat is an Allis-Chalmers trademark.

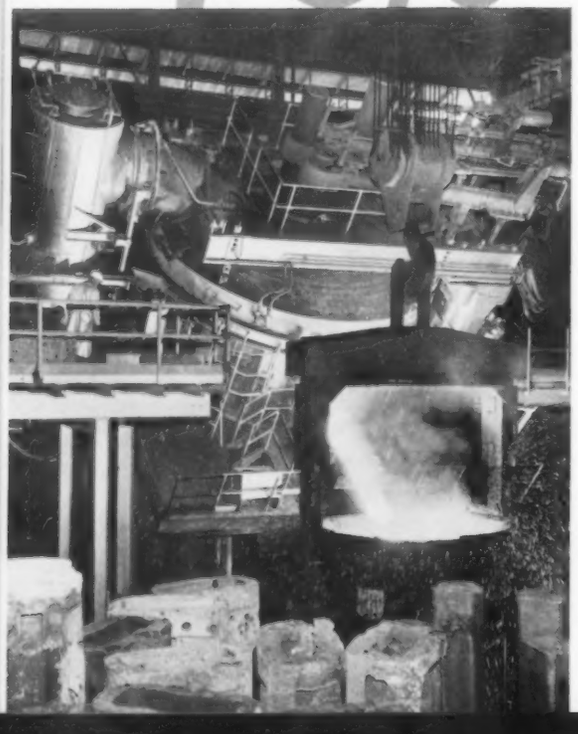
A-C ALLIS-CHALMERS

A-5808

Pennsylvania Furnace Transformers help BOOST INGOT CAPACITY 70%



One of two such units at a leading West Coast steel plant, this 25,000-kva Pennsylvania Furnace Transformer is helping set new production records at lower cost per ton. The transformers supply power to two 100-ton Lectromelt Furnaces—also products of McGraw-Edison Company.



Two 25,000 Kva Transformers Team up with Lectromelt Furnaces in Replacement of Open Hearths

Replacement of gas-fired and oil-fired open hearths by two 100-ton Lectromelt Furnaces has increased the annual capacity of a leading West Coast steel mill from 246,000 to an estimated 420,000 ingot tons per year . . . while costs per ton have been substantially lowered.

A dependable, efficient source of power is of prime importance in the establishment of such a record. Two 25,000-kva Pennsylvania Furnace Transformers are meeting the challenge—converting the 34,500 volts supplied by the utility to low voltages that range from 450 to 300 volts. The maximum line current is 37,100 amperes.

Pennsylvania Furnace Transformers can withstand the repeated short circuits and heavy overloads that are characteristic of such service because of design and construction features that have stood the test of decades. These include electrically balanced, precompressed coils . . . extra sturdy bracing of coils and bus bars . . . and a coil design in which individual conductors are transposed to reduce copper eddy losses.

To reduce down time during periodic inspections, the motor-driven tap changer is housed in separate compartments that are isolated from the main tank. The tap changer has a provision for emergency hand operation.

To take advantage of Pennsylvania's unsurpassed know-how and record in the design and manufacture of furnace transformers, contact Pennsylvania Transformer Division, McGraw-Edison Company, Box 330, Canonsburg, Pa.

McGRAW EDISON

Pennsylvania Furnace Transformers

PENNSYLVANIA TRANSFORMERS

Advances at Weirton

by L. A. Fugassi,
Assistant Chief Engineer
Weirton Steel Co.,
Div. of National Steel Corp.,
Weirton, W. Va.

Figure 1 — Hand hot mills were an important factor in the early growth of the Weirton Steel Co.

Figure 2 — In World War II, Weirton made important contributions to the war effort with their shell program.

WITH the 1905 purchase of the Phillips Sheet and Tin Plate Co., in Clarksburg, W. Va., which had been operated as an eight mill plant when purchased and which was enlarged to 12 mills in 1907, the Weirton Steel Co. had its beginning. The Weirton plant was started in 1909 with ten hot mills, and ten more were added the following year. In 1911 a 12-mill plant was acquired at Steubenville, Ohio by the purchase of the Pope Tin Plate Co. By 1915 Weirton was operating 50 hand hot mills and was the largest independent producer of tin plate. Also, in 1915 a cold rolled strip plant was installed at Weirton. It is interesting to note that on August 1, 1918, the forty-third birthday of E. T. Weir, founder of Weirton Steel Co., the entire company name was changed from Phillips Sheet and Tin Plate Co. to the Weirton Steel Co. One of the first installations in 1919 was the No. 1 blast furnace which originally had an 18 ft −6 in. diam hearth and was 92 ft high.

By the end of 1920 the Weirton plant consisted of seven open hearth furnaces, 100-ton capacity each; a 40-in. blooming mill; and 21 and 18-in. continuous rolling mills. Starting in 1918 Weirton began integration by acquiring ore properties in the Lake Superior region, large tracts of coal in Pennsylvania, and the required railroad equipment. Also, during this time a 150-ton per day sintering plant was erected, 37 coke

Progress at Weirton Steel has featured units capable of high speed, high power, and high production designed to produce quality products.

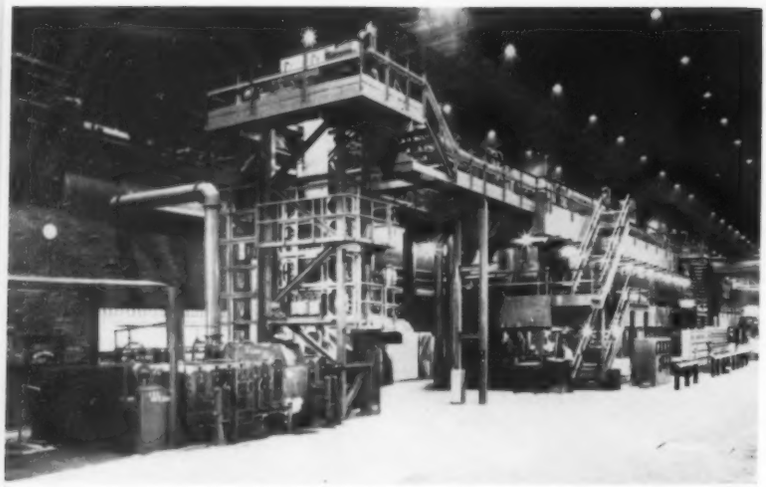


Figure 3 — Development of differential coating was an important factor in the economical usage of tin in tin plate.

ovens went into operation, and the Sheet Mill Division was built.

In 1927 a 48-in. hot strip mill was placed in operation. This was the world's first fully continuous hot mill designed to produce wide, flat rolled, light gage steel. At the same time two four-stand, four-high cold mills were installed.

New installations prior to 1925 included turbo-generators, soaking pits, an additional open hearth, river docks, and continuous picklers. In 1929 the National Steel Corp. was organized, and Weirton's first temper mill, 20 x 48 in. x 2-high, was installed in what was then the 48-in. and which is now the 54-in. Strip Steel Dept.

During the period from 1930 to 1945, additional equipment was added at both the Weirton and Steubenville plants including temper mills, the No. 3 blast furnace, high pressure boilers, warehouse and dock facilities, the No. 2 bessemer, and a 35-in. bloomer. Also, the structural mill was modernized.

During this time Weirton was experimenting with a pilot line for electrolytic tinning and in 1943 installed three of the first high-speed electrolytic tin lines designed to plate strip steel at speeds up to 1000 fpm. These lines were installed with horizontal plating cells and were the first of their type ever installed.

Meanwhile the company took on additional non-related work. In 1942 equipment for rolling copper-clad steel and for making cups for the 30 and 50-caliber machine gun shells was installed.

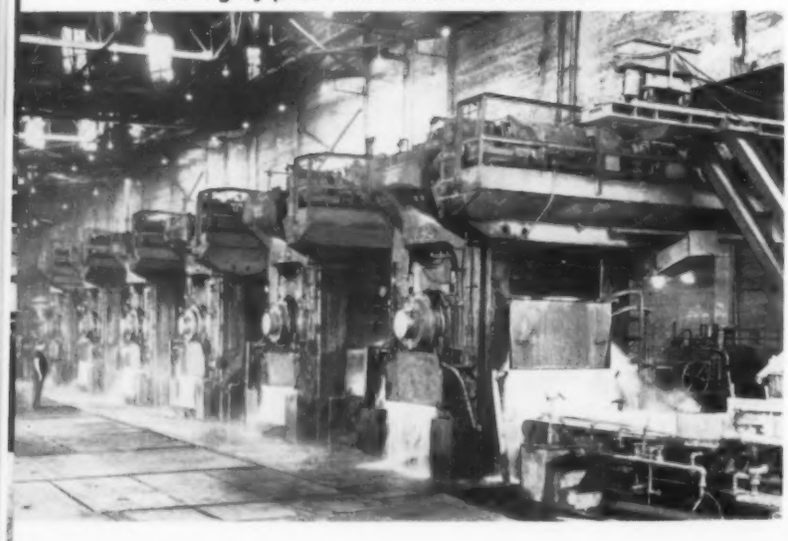
Also, in 1944 Weirton made another contribution to the war effort by installing a complete plant for manufacturing the ME 108 howitzer shell, starting with the billet on the structural mill and ending with a painted shell ready for loading with high explosive by the Army Ordnance Division. Work on this high explosive shell manufacture was started in March, 1944, and Weirton is proud of having produced 13,000 shells per month only 189 days after starting the program. This plant achieved a record production of 76,000 shells per month in May, 1947.

With the change to continuous electrolytic tin plating, Weirton also began continuous electrolytic zinc plating. We foresaw the tremendous increase in tin plate requirements. Accordingly, the hot mill was improved by the addition of a 28 x 90-ft slab heating furnace and additional slab yard capacity. Also, the No. 3 tin line capacity was increased. To help roll the additional steel from the hot mill, the worlds fastest (at that time) five-stand tandem mill was installed with a top speed of 5000 fpm. Cleaning line, annealing, temper pass, and coke oven capacities were increased. The power supply system and the blast furnace were enlarged. During this time continuous galvanizing line operations were begun in the sheet mill.

In 1949 the largest stationary open hearth furnace in the steel industry went into operation. The No. 1 furnace was rated at 550 tons. Higher speeds and ratings were fast becoming a byword at Weirton. Also, during this year four new annealing furnaces, which were the largest ever made, went into operation in the tin mill. These annealing furnaces could handle 66-in. diam coils at a rated capacity of eight tons per hr, and each furnace could hold 240 tons of coils.

The first 5000-fpm temper mill also went into operation. When we first began experimenting with temper rolling in 1929, we used two old cold mill stands, with 28-in. rolls, as the temper mill. Experience proved that making a range of tempers for tin was very difficult. During that time we were also operating a four-stand small-diameter roll mill which seemed to be more flexible for controlling temper. So our next attempt at a temper mill was a four-high mill with 8-in. diam work rolls and a second two-high stand with 28-in. diam rolls. We found that this installation would permit temper control on the first stand only with the second stand for shape and surface control. The results were satisfactory, and this type of temper rolling was made standard. When No. 3 went in, the work roll diameter was increased to 9 in. mainly to accommodate larger bearings for the higher speeds. The original mills were 2600 fpm. Again with the No. 4, 5000-fpm skin mill, the rolls were increased to 10 in. on the same basis. Since we also produce weirzin, an electrolytic-deposited zinc coating in sheet gages, the new No. 4 mill was made a combination mill with a top and bottom screwdown so that either 10 or 20-in. diam work rolls could be used for tin and sheet gage material.

Figure 4 — The hot strip mill is one of the most powerful and highly productive units in the world.



In 1950 61 more coke ovens were added. The latest electronic devices were installed to speed steel inspection and production. Also the world's fastest electrolytic line went into operation. The No. 4 electrolytic tin line was designed to operate at speeds up to 2000 fpm.

Weirton began development of differential coating, and in 1951 this latest development was made a regular product of the Weirton Steel Co. Considerable tin saving resulted from this method because heavier tin coatings could be applied to the surfaces where it was required without applying it to surfaces which did not require as heavy a tin thickness. The design of our 2000-fpm No. 5 tin line provided 21 plating cells on the first pass and 11 cells on the second pass in order that differential coatings could be made at full speed.

The production spiral was again rising; No. 13 open hearth furnace, rated at 550 tons, was put in operation. National's management also began iron ore development in Labrador in conjunction with associated steel companies.

The four-year period prior to 1955 saw a detinning plant and the No. 4 blast furnace and related equipment, put into operation the Ernest T Weir, a new iron ore carrier, launched at Lorain, Ohio; and new continuous galvanizing lines, 41 additional coke ovens, high-pressure boiler facilities, and a 2500-ton per day sintering plant installed.

To keep pace with required production, the year 1955 saw one of the most modern hot strip mills put into operation. The roughing stands were made two-high. After many discussions and visits to other hot mills 35-in. diam two-high roughing stands were selected because it was felt the contact area of the roll with the bar would give a double advantage: first, the resultant larger area would help prevent slipping, and second, a greater reduction could be taken on a larger roll without chattering than with a smaller roll; second while the old mill was operating, it was found that increased slab thickness caused a distinct chattering in the mill. Four-high roughers with 18-in. work rolls were being used. Because the new mill was designed for up to 9-in. slabs, it was felt that the small roll would be unable to take the increased duty cycle load. This was the reason for the decision to use the larger rolls. We are now using a fluted roll in the first stand and smooth rolls in the other two stands. Reduction averages on an 8-in. slab are approximately 22, 40 and 43 per cent through these two-high roughers. Also, oil bearings which are duplicates of those in the finishing stands were selected. The backup rolls start in the finishers at 49½ in. diam. and are taken out of finishing stand service when they wear to 45 in. diam. At this point they are put into the No. 4 and 5 stands, which are 49½ in. and 35 x 54-in. four-highs. The backups are worn down to about 44¼ in. in No. 4 and 5 roughers at which time they can either be sleeved and reused in the finishers or used in the 44 x 54-in. two-high stands.

It was proposed that this 44-in. roll be used in the two-high roughers until worn to about 36 in. at which time they would be scrapped. However, we have not as yet reached the point where our rolls have had sufficient wear to determine the feasibility of this. The work rolls in No. 4 and 5 stands start at 35 in. and are taken out of service at 31½ in. diam. The

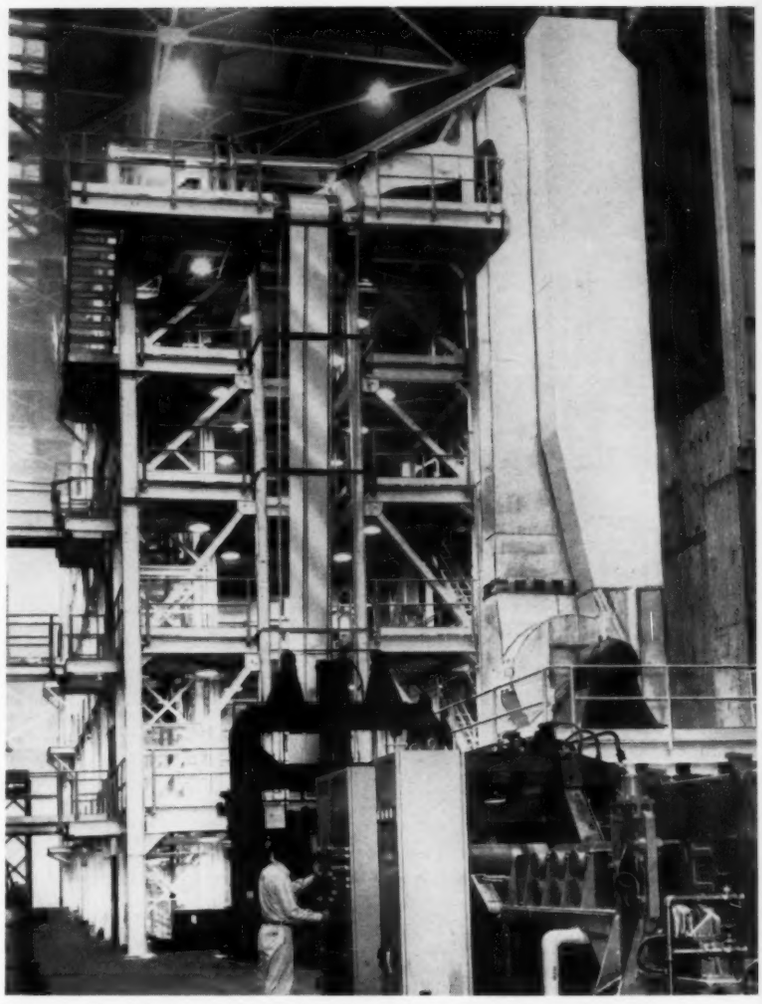


Figure 5 — Electrogalvanizing lines have largely replaced hot dip units since the war.

work rolls in the finishing stands are 26¾ in. this size was selected so as to give more cooling surface and allow better control of the roll heat than the 23½-in. work rolls which were originally in the mill. These rolls are worn to 24½ in. and then scrapped. The finishing stand work rolls are ground flat for service and are iron rolls except those in the No. 6 and 7 stands where we use about a 0.015-in. concave cast steel roll. This concavity, of course, is used because the steel will swell more than the iron in service. All backups are alloy cast steel and the sleeves are forged steel.

Carrying this through 1956 we put into operation a new high-speed coil pickler, the world's fastest; a 7000-fpm five-stand tandem mill; another 6000-fpm temper mill; and a 3500-fpm skin mill for sheet gages. No. 3 and 4 continuous coil galvanizing lines were started and featured a five-pass horizontal annealing furnace and the world's fastest continuous cleaning and annealing line at 2000 fpm. Sandwiched into this program were 280,000 sq ft of new buildings together with a packaging unit, three new continuous shearing lines, and continuous scarfing and new circular annealing facilities. Soaking pits were installed, and an additional ladle house and cinder yard extension were added to the steel works facilities.

On December 22, 1956 the new No. 14 open hearth, rated at 600 tons was tapped, and on the first day's

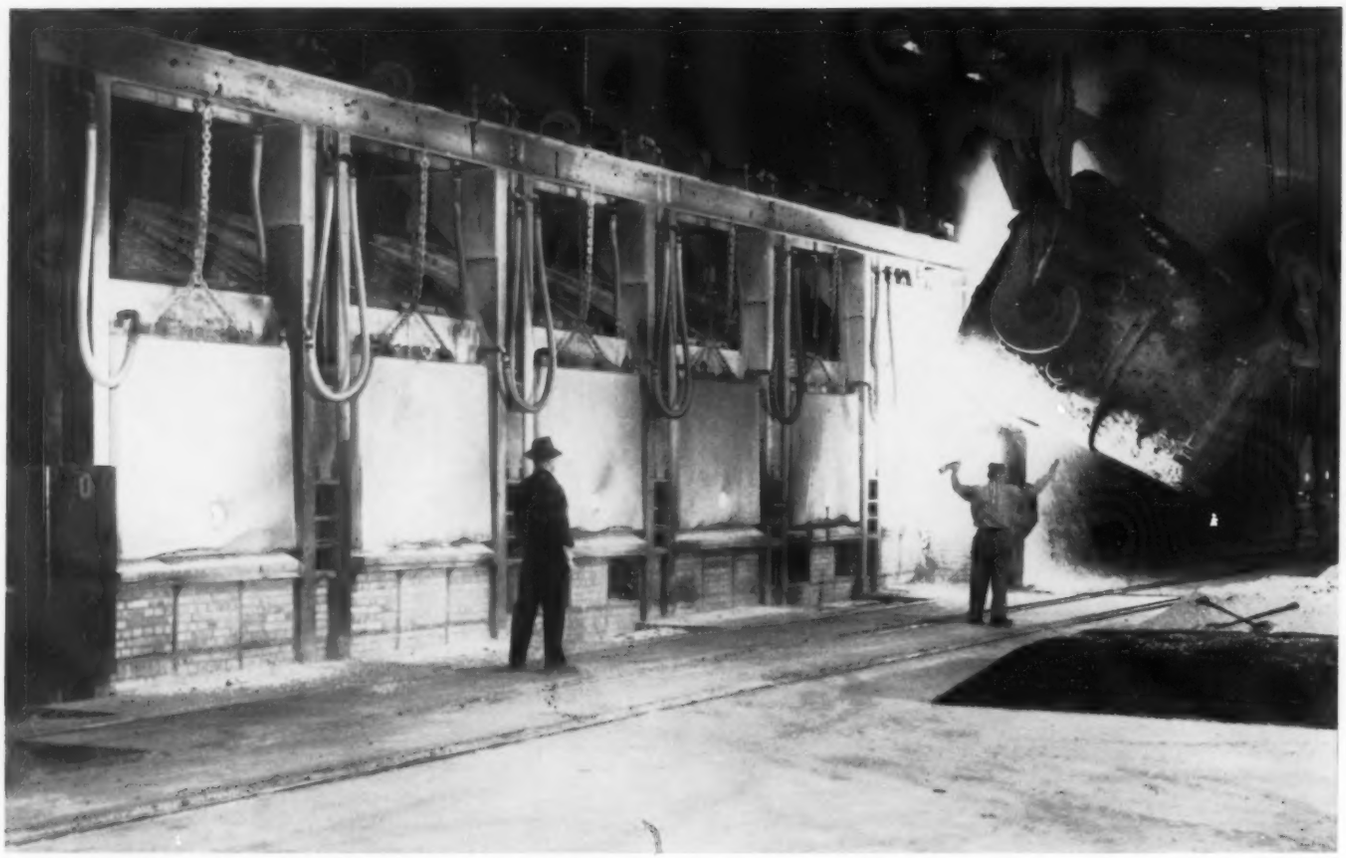


Figure 6 — Weirton's new No. 14 furnace is setting production records.

run we doubled the furnace producing 558.5 tons on the first heat and 538.5 on the second heat. A question may be raised as to why Weirton selected these high-tonnage furnaces. When the first open hearths were installed they were 100 tons. As more furnaces were added the open hearth shop became crowded. We had an advantage in that about 80 per cent of the product was low carbon steel primarily used for tin plate. The shop was not required to make a wide diversity of steels. It seemed feasible to enlarge the furnaces for high ratings to conserve space. The No. 1 furnace installed in September 12, 1949 was built into the space formally taken by a 200-ton furnace. It increased the furnace capacity to 550 tons without sacrificing valuable shop space. Again, the No. 14 furnace was fitted into the available space. It was the first 600-ton furnace. We have recently installed basic brick in the roofs and chill and end walls in certain other furnaces. On the No. 10 furnace installation of a basic roof and two oxygen lances tripled its capacity, now rated at 450 tons. This is fast becoming a common practice. After a few days in production three heats, totaling 1275 tons, were tapped in one day. In October 1958, a basic roof and three lances, were put in No. 14.

Recently the new 6000-ton per day sintering plant went into operation together with limestone handling facilities making possible production of self-fluxing sinter. The sinter bed is 12 ft wide x 147 ft long and has an active grate area of 1784 sq ft. There are 14 divided wind boxes and two collector mains, one on each side. The hot dirty gases pass through four parallel cyclone type dust collectors in each main into a fan. The two fans are each rated at 255,000 cfm, 36-in. suction, 350 F, and are driven by 2500-hp synchronous motors. Total air on the machine is 510,000 cfm or 123,000 cu ft of air per ton of sinter based on a 6000-ton per day rate of production. The breaker is the spike roll type which breaks up the sinter before it is passed over the hot screens. There are two parallel hot sinter screens with the tops, of the screens delivering to the cooler. The fines fall into a hopper and are taken back to the main raw mix. It is interesting to note that both hot screens are in service at the same time and are arranged on shuttle tracks so that they may be removed from the screening area for easy access and repair.

The cooler bed is 10 ft wide x 150 ft long giving an effective grate area of 1500 sq ft. There are two fans each of 252,000 cfm, 6-in. static pressure at 70 F, and they produce a total equivalent of 121,000 cu ft of air per ton based on the 6000-ton per day rate of production. There are two cold sinter screens mounted on a motorized carriage and shuttle rails so that while one is in the operating position the other screen is in the open for repair. Belt conveyors deliver the sinter to bins on the high-line.

All equipment installed since 1956 for tin plate products is designed for 45-in. wide strip.

In conclusion, it is felt that the constant improvements being carried on in all departments will result in a higher quality product that will enable us to take full advantage of the power and speeds built into our equipment and quite possibly in the very near future to exceed these figures. This may sound optimistic, but 15 years ago the present scope of steel industry production facilities seemed out of the realm of possibility. ▲

The weight reduction effect of aluminum construction for overhead traveling cranes makes possible higher material handling rates by permitting higher bridge and trolley accelerations and speeds for the same drive equipment and runway foundations; or it reduces costs for runway foundations and bridge and trolley drive equipment for a given payload . . . . the lesser maintenance required by an aluminum crane can offset its installation premium in 20 years.

by A. H. Koepf, Product Development, Kaiser Aluminum & Chemical Sales, Inc., Oakland, Calif.

A REVIEW OF ALUMINUM CRANES

THE traveling crane is a prime method of handling materials and equipment. It takes two basic forms of construction. The overhead traveling crane is installed straddling elevated supporting ways while the gantry type traveling crane is supported from grade with extended legs to provide working space.

Overhead traveling cranes have many advantages for industrial use. Among the advantages are they neither occupy nor cause obstructions in floor working space and tend to permit straight-line carrying of loads without seeking routes among objects on the floor. Construction with support at both ends allows use of minimum structural material to meet load-rating design at any point in the area. The necessary end supporting structures, located along the walls of a building or edge of a yard, may be a part of the building construction, eliminating the need for some additional members. For these reasons, the overhead crane is especially well suited to heavy industrial applications. This suitability is reflected in its widespread use. Figure 1 shows a typically installed aluminum overhead traveling crane.

Gantry cranes serve the same purpose as the overhead crane. Construction is different because economies prefer that it be designed to carry its own end support elevation frame. The same advantages of overhead crane space coverage and handling feasibility apply to this special type crane.

A third class of cranes utilizes a boom for area coverage, particularly in unloading bulk materials.

The discussions herein can be extrapolated to welded or riveted booms with design, costs, and service similar to conventional traveling cranes.

The purpose of this discussion is to review the process of crane engineering, procurement, and service in terms of the effect of aluminum application. For this reason, discussion of crane components, equipment, design and economics will be evaluated where application of aluminum may have a marked effect on the crane.

ADVANTAGES OF ALUMINUM

There are but two major reasons for the consideration of aluminum for traveling cranes: lower weight and reduced maintenance. Roughly, an aluminum crane will have a dead weight of close to 60 per cent of a

Figure 1 — One advantage of overhead traveling cranes is they do not occupy floor space nor do they obstruct operations in any way. Shown is a crane of aluminum construction.

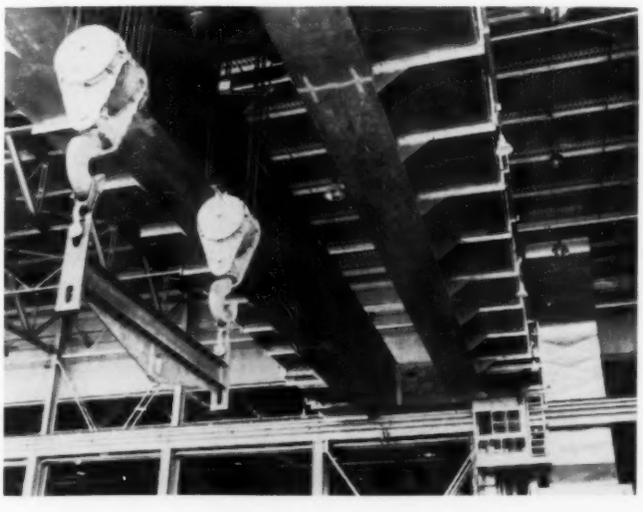


TABLE I
Types of Cranes

Crane type	Service	Applicable specification	Capacity lifts per hour
A. Light	Intermittent light duty	None	To 10
B. Standard industrial cranes	Standard industrial medium duty	EOCI Spec. 49, 1949 or AISE Std 6, 1949	10–40
C. Mill type cranes	Steel mill heavy duty	AISE Std 6, 1949	40–80
D. Gantry	Standby to heavy duty	EOCI Spec 49. or AISE Std 6	Varies
E. Booms	All	ASCE Paper 970 or AISE Std 6	Varies

EOCI—Electric Overhead Crane Institute.
AISE—Association of Iron & Steel Engineers.

steel crane, including all equipment. This reduced weight can be made useful in several ways: increased lift capacity without increase of wheel loads, reduced wheel loads and foundation sizing without reduction in lifting load, increased acceleration and velocities without penalty in drive horsepower, or reduced horsepower requirements at equal acceleration and speeds. Translated into end results, the lower weight of aluminum will permit more material to be handled either at higher capacity lifts or higher speeds, making the handling efficiency of the operation improve.

Reduced maintenance results because of the absence of painting costs and reduced wear on moving parts. The lighter crane with considerable resiliency causes much less pounding on the runways, trucks and bearings, prolonging the life of all mechanical components.

TYPES OF CRANES

There are many types of overhead or gantry traveling cranes in commercial application today. For purposes of discussion, these may be combined into the four basic groups outlined in Table I. The possible uses of aluminum will vary in each of these classes, use being dependent upon the governing design codes and concepts, competition, pricing, and the performance and sizes of cranes. Generally, crane components of welded construction, particularly free span massive shapes, will be the most attractive aluminum applications.

Referring to Table I, the first cranes are the light service group. These cranes are intended for light and intermittent service over short spans. The girders usually consist of standard structural steel, wide flange beams with structural shapes making up the trolleys. The hoisting and travel equipment is designed for slow lifting and motive speeds and intermittent operation as shown in Table II. Spans are usually limited to about 50 ft and capacities to 50 ton, spans being reduced as capacity increases. These cranes are not engineered to a definite code requirement but generally follow the intent of the Electric Overhead Crane Institute Specification 49. Aluminum usage in cranes of this type will be severely limited due to short spans, low dead weight, and economics induced by the highly competitive status of the industry.

Standard industrial cranes are designed in accordance with the Electric Overhead Crane Institute Specification 49 and in some cases the Association of Iron & Steel Engineers Standard No. 6. Specific performance requirements vary from intermittent to continuous heavy duty materials handling. Requirements may vary from power plant or flood control service with infrequent intermittent service to magnet or bucket production cranes in continuous heavy duty operation. Speed variation within this group is from slow operational speed for intermittent service cranes to rapid speeds for heavy duty cycle operation as indicated in Table II. Typical spans will range from 60 to 150 ft with load capacities from 5 to 200 ton. Aluminum weldments are more feasible on the heavy duty or long span cranes than on the light, short cranes.

Mill type cranes are engineered for continuous duty cycle service. Specifications for this type crane follow the AISE Standard No. 6. Speeds are usually high so that short duty cycles may be maintained as indicated in Table II. Typical spans and capabilities are 70 to 180 ft and 10 to 250 ton. Conservative design requirements and high load capacities result in very heavy structures for this type of crane. The advantages of aluminum structures in this operating range are most pronounced.

The bulk of a gantry crane, its girders, trolleys, end ties and equipment, may be considered equivalent to comparable overhead traveling cranes with the addition of the end supports. The most common application of this type crane are outside yard service and equipment handling units for power plants, dams, shipyards and other outdoor stations. These cranes may be constructed to specification by owner, EOCI Standard 49, AISE Specification No. 6 or any equiv-

TABLE II
Typical Speeds For Aluminum Cranes

Capacity, tons	Hoist speed, fpm			Trolley travel speed, fpm			Bridge travel speed, fpm		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast
5	25	40	60	100	150	200	150	300	500
10	30	55	90	100	150	200	150	300	500
20	15	28	40	100	150	200	150	300	500
30	10	18	30	100	150	200	150	300	450
40	6	12	30	100	150	200	125	300	400
50	6	12	25	80	150	200	100	300	350
75	4	9	20	50	125	200	50	200	300
100	4	8	15	50	125	150	50	200	300
125	3	6	10	40	100	150	50	150	250
150	3	5	8	30	80	150	50	150	200
200	3	4	6	25	60	100	50	100	150

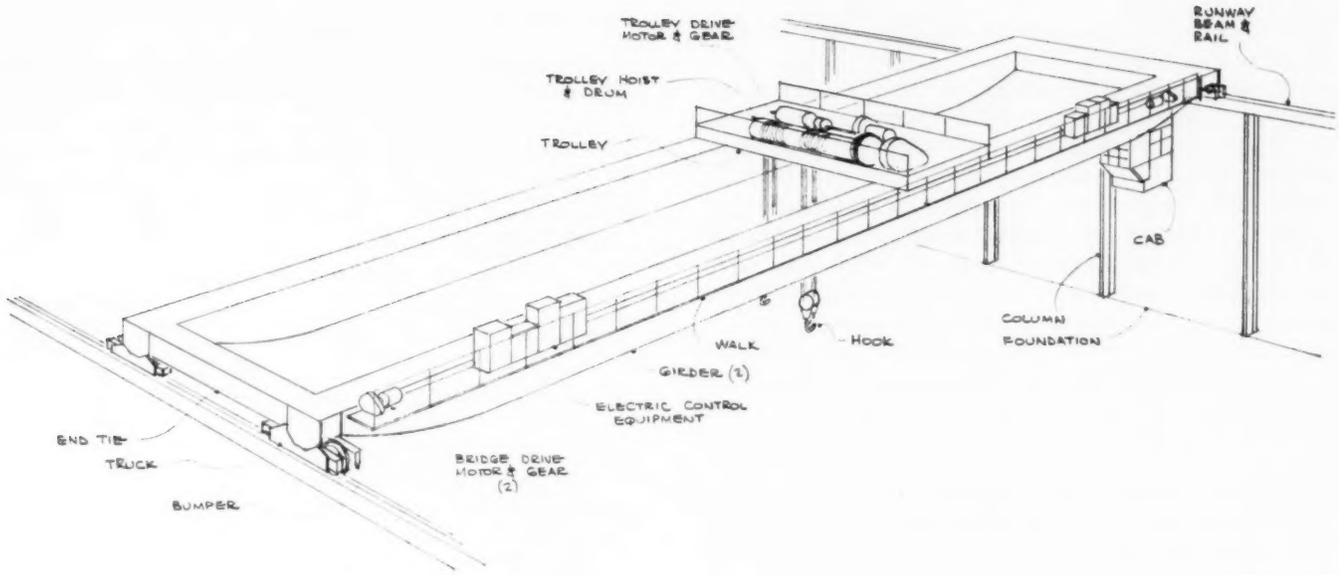


Figure 2 — Typical overhead traveling crane.

alent. Spans, capacity, and speeds vary widely within equivalent application ranges of other traveling cranes. Because gantries are normally outdoor installations, aluminum application on these cranes have added advantages because of its better corrosion resistance.

CRANE COMPONENTS

A convenient grouping of the components making up an overhead traveling crane would be:

Structures	Miscellaneous	Equipment
Girder	Walks	Gear cases
Trolley	Ladders and railings	Resistor racks
End ties	Cab	Collector rails
Bumper	Safety guards and plates	Electrical machinery
Trucks		Mechanical machinery

The assembly of these components into a typical overhead traveling crane is shown in Figure 2.

It is to be expected that aluminum usage may vary widely as it will be governed by the service and maintenance return to the user for cost factors that may be added. A reduction in weight applied to the crane may be absorbed by savings in other plant construction or machinery items.

The main structural components of the crane represent the most promising group of aluminum applications. They represent approximately 50 per cent of the entire dead weight of the crane in aluminum and 65 per cent of the equivalent steel crane. It should be noted that the dead weight of the steel girder, being distributed uniformly for a long horizontal span, alone may vary from 0.7 to 5.0 times the lifting capacity of the crane. Because of this structural weight ratio, a reduction in dead weight of the crane girder alone will significantly reduce load carrying requirements. Thus, in considering the stresses and deflection developed in a crane girder, it is possible to take full advantage of weight reduction due to aluminum; and highly attractive weight ratios of aluminum to steel are obtainable. In addition, a reduction in dead weight of the girder may result in a size reduction of driving machinery for given girder speeds and accelerations. The net combination is that aluminum girders offer very attractive applications in cranes.

The trolley offers a second opportunity for aluminum application in crane construction. Similar to the girder, the trolley must be capable of moving to any point in the span. It contributes additional dead weight to the girder and trolley system. The use of aluminum has no effect on hoisting power requirements but results in a small reduction in trolley drive power due to weight as well as the sizable reduction of the power requirement for the bridge or girder. The light weight is reflected in shorter trolley duty cycles with higher accelerations and velocities. The weight ratio for aluminum to steel is somewhat higher than would be expected for the girder but is still sufficiently low to make this an attractive application for aluminum.

The end ties, bumpers and trucks offer a third application for aluminum that should be considered. Reduction in weight at the ends will have no effect on the girder or trolley system of the crane but will influence gross loading on the crane rails and reduce the wheel loads. In this application, the aluminum-steel weight ratio may be very attractive due to lower stress levels. It is suggested that aluminum be considered on this portion of the cranes when high wheel loads pose a serious construction penalty to the structural framing system and foundations, or where the corrosive environment is equally severe

The miscellaneous metal group includes all the accessories installed to improve the maintenance performance of the crane, consisting of walkways, ladders, cab, safety guards and deck plates. The walks are designed to run the complete span of the girder. While they furnish no structural assistance to the girder, they do increase its dead weight; and very attractive weight ratios of aluminum to steel will be obtained. The cab may be located anywhere in the structure, though normally at one end, and may be constructed of aluminum

using a variety of structural shapes and sheet which eliminate finishing requirements.

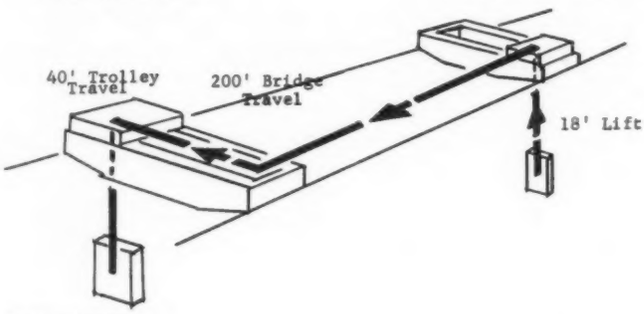
The next group of aluminum applications covers the equipment structures that make up the crane system. The direct substitution of aluminum will save considerable weight on gear cases, resistor racks, and collector rails. These weights are frequently applied within the span of the girder, and weight reductions may be used to further reduce the girder requirements. Combining the weight reduction of aluminum and its advantageous characteristics of heat transfer, corrosion resistance, lack-of-finish requirements, and electrical conductivity; aluminum becomes economically practical. This is the region where the designer must use his best judgment by balancing the crane performance against the cost addition.

To this point, the prime purpose for the use of aluminum is to reduce the dead weight of the structure. The equipment group covers the machinery required to provide motive power for the crane. The hoist machinery is independent of the crane structural framework, and no economies or reductions are possible here. However, the trolley machinery may be reduced in size somewhat where the designer desires equal trolley speeds and accelerations, as the moving weight is lower with aluminum. The bridge drive machinery offers substantial reductions due to the large weight reduction permitted by the use of aluminum in girder construction. For equal speeds and accelerations substantial economies are possible.

TABLE III

Duty Cycle Comparison of Aluminum and Steel Overhead Traveling 10-Ton Cranes With the Same Drive Equipment

	Aluminum	Steel
Speeds		
Hoist speed, fpm	55	55
Trolley speed, fpm	200	150
Bridge speed, fpm	500	400



Cycle elements		
Close contact, sec	7.0	7.0
Hoist (18 ft), sec	19.6	19.6
Bridge travel (200 ft), sec	24.0	30.0
Trolley travel (40 ft), sec	12.0	16.0
Open contact, sec	7.0	7.0
Trolley return (40 ft), sec	12.0	16.0
Bridge return (200 ft), sec	24.0	30.0
Lower (18 ft), sec	19.6	19.6
Total per 10-ton load, sec	125.2	145.2
Ratio of aluminum cycle to steel cycle	0.861	
Increased production possible with aluminum crane	16.4	per cent

OPERATION AND DUTY CYCLE

Normally, the basic reason for substitution of aluminum for steel is on the basis that performance is not sacrificed. Service advantages are shorter duty cycles, reduced wheel loads, longer mechanical life, and freedom from structural maintenance.

The theme of weight reduction has been applied to cases where equal speeds and accelerations have been the governing criteria in aluminum and steel comparisons. However, the crane user may decide to take advantage of some of the weight reductions of aluminum by improving his duty cycle. This is important in car unloading, bucket handling, magnet handling and ingot transferring. In many cases, the crane capacity, expressed in units per hour, limits the total production of a plant. If an increase in duty cycle can be obtained, an increase in plant production can be had. Let us take an example duty cycle to show the advantages of aluminum over steel. Referring to Table II of typical crane speeds, let us compare the medium speed classification of a 10-ton steel crane and fast speed classification for a 10-ton aluminum crane. This is justified by the dead weight of an aluminum crane being sufficiently low so that terminal speeds of 25 to 50 per cent more than steel can be designed into the structure without major increase in stresses or horsepower requirements. Review of the duty cycle shown in Table III reveals the duty cycle for the 10-ton aluminum crane to be 125.2 sec per lift or 16.4 per cent less than the steel crane. All other factors being equal the aluminum crane will increase plant production 16 per cent. It is in this area of application that aluminum holds high promise, offering continuous duty, high-speed cycles for material handling. The example in Figure 1 is an aluminum crane of 10-ton capacity selected over steel because it provides 25 per cent more ingot handling capacity for an aluminum rolling mill.

Another advantage of the light weight crane, which cannot be directly attributed to the cost of the crane alone, are the savings it affords in foundation, column and craneway systems. It is common practice to let the craneway structure double as the side wall frame for a building. Foundations must invariably be designed for the crane load because the building load is frequently but a small percentage of crane loads. The substitution of aluminum in the crane will result in a direct reduction in wheel loads and a direct reduction in foundation and supporting structure loads. In new construction the wheel load reduction will either eliminate the need for piling or contribute to a substantial reduction in pile requirements at an attractive savings. Where additional capacity is desired on existing craneways, the cost of modifying the craneway, column structure and foundations may be very high. An application for aluminum cranes would be replacement units when additional lifting capacity, up to 40 per cent more, without increase in wheel loads on the craneway system, is desired.

A high reduction in dead weight of the crane offers further savings in mechanical equipment size and wear. This can be expressed in increased bearing life, increased wheel life and substantially reduced maintenance of craneway rails. If the weight reductions are sufficient, it is also possible to provide lighter crane rails, wheels and bearings.

The structural maintenance of the crane will be considerably reduced due to the high resistance of aluminum to atmospheric corrosion. On an outdoor installa-

TABLE IV
Fixed Design Limits For Welded Girders

Symbol ratio	Code	
	AISE Std 6	EOCI Spec 49
L/H	18 max	...
L/b	60 max	55 max
b/t_c	*	60 max
h/t_w	*	240 max
t_w, c	5/16 in. min	...

* Limit expressed in terms of stress. See Figure 5 for description of dimensional symbols.

tion, this means that routine painting, during the life of the crane, may be largely avoided. Indoor cranes normally are not painted often enough to offer substantial economies for aluminum, but sporadic maintenance, painting, finishing, and cleaning may be largely minimized by the use of aluminum in its natural finish.

STRUCTURAL DESIGN CODE LIMITS

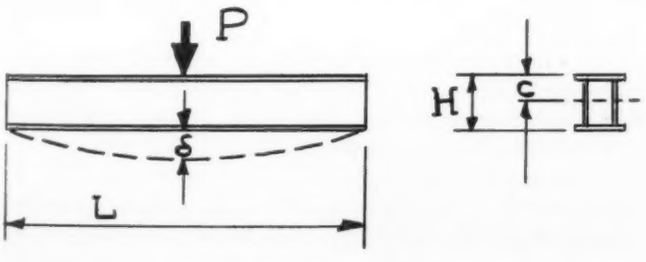
An aluminum crane is designed using the same procedure employed in design of steel cranes. The only modification required in the designer's thinking is realization that he is designing to lower allowable axial, bending, shear and buckling stresses. Background data requirements for design application of aluminum must, therefore, include code discussion, alloy selection, and design stresses before detailed design can commence.

As described previously, crane design is governed by either the Electric Overhead Crane Institute Specification No. 49 or the Association of Iron and Steel Engineers Standard No. 6. These specifications are both specifically written for steel, requiring certain safety factors for stresses, maximum deflection, and some minimum sizes and gages as the basic means of design control. Aluminum cranes may be designed to meet the same desired conditions as indicated below.

The EOCI and AISE sets certain safety factors. Shear and buckling stresses plus stiffener and diaphragm selection are similarly limited by standard stress factors and design practices outlined in these codes. Aluminum cranes are, it is expected, to be designed to meet the intent of these codes.

Both codes limit the shape and minimum gages of the girder. They control such things as depth to span ratio, shear web configuration, and stiffener spacing so as to make design of girders fall within very narrow limits. Again, all these requirements are compatible with aluminum design and may be included as desired. The details of these limits are tabulated in Table IV.

Figure 3 — Simplified beam for girder stress and deflection calculations.



DEFLECTION

Both codes limit the maximum deflection of the girder just as they limit the size. The 1949 AISE Standard limits deflection of the girder to 0.001 of the span with a combined load of lift and trolley weight but without impact or dead load. The EOCI limits deflection to 0.00125 of the span for combined loads of lift, trolley, and the dead load of the girders and walks. The 1942 AISE Standard limited deflection to 0.0015 of the span, but this was changed in the 1949 code to restrict the maximum design stress of the steel and prevent the possibility of creep of trolleys.

After the establishment of stress, size, and deflection limits, a detailed review of the influence of deflection on stress will be undertaken to emphasize the low equivalent levels of aluminum cranes. It is a simplified case of a rectangular girder of constant section and center concentrated load, as shown in Figure 3, is assumed; approximation equations of stress and deflection yield:

$$S = \frac{PLc}{4I} \tag{1}$$

$$\delta = \frac{PL^3}{48EI} \tag{2}$$

If equation (1) and (2) are transposed, a stress equation is developed as follows:

$$S = 12E\left(\frac{\delta}{L}\right)\left(\frac{c}{L}\right) \tag{3}$$

If the beam section is uniform about the center axis, i.e. $c = \frac{H}{2}$; the following equation results:

$$S = 6E\left(\frac{\delta}{L}\right)\left(\frac{H}{L}\right) \tag{4}$$

Now, since the codes restrict δ/L and H/L to maximum limits, they in turn define the maximum allowable stresses. As an example, from the AISE Standard which limits H/L to $\frac{1}{18}$ and δ/L to 0.0010 in the 1949 code or 0.0015 in the 1942 code, the stress levels of Table V due to vertical load can be obtained from equation (4).

In the case of steel design, the higher deflection level of the 1942 AISE Code proved to be somewhat higher than was desired, and this was a partial reason why the code was amended. In the case of aluminum either stress level is substantially below the ordinary stress limits for structural design. Several aluminum cranes have been manufactured and operated successfully under the older code deflection requirement without detrimental stressing or creeping.

The stress requirements stipulated by the Electric

TABLE V
Design Specifications and Allowable Bending Stresses Using Equation 4

Structural Material	E, psi	δ/L	H/L	Maximum allowable bending stress in girder, psi
Mild steel	29×10^6	0.0010	1/18	9650
		0.0015	1/18	14400
Aluminum	10.3×10^6	0.0010	1/18	3430
		0.0015	1/18	5150

Overhead Crane Institute are of the same general order of magnitude as set forth in the 1949 AISE Standard. The actual allowable stress in aluminum will be slightly lower than the 1949 AISE Standard, but the difference from a preliminary design standpoint is negligible.

ALLOYS

Although there are a vast number of alloys of aluminum commercially available, only two groups of aluminum alloys can realistically be considered for heavy welded structural applications such as aluminum crane construction. These alloys are the non-heat-treatable 5000 series, containing magnesium as the principal alloying element, and the heat-treatable 6000 series, combining magnesium and silicon as their principal alloying agents. These two alloy groups lend themselves to common fabrication and welding processes.

The high magnesium content alloys, represented commercially by alloys 5086, 5083, 5154 and 5456, derive their strength from the modification of grain structure imparted by the addition of magnesium to aluminum. Magnesium content varies from approximately 3.5 to 5.5 per cent. These alloys are non-heat-treatable but gain high strength by cold working or strain hardening. Magnesium-aluminum alloying produces material of high strength that may be readily welded without significant loss of ultimate strength while still retaining high ductility in the welds. Their corrosion resistance is very high, these alloys being commonly used in severe marine atmospheres. Mechanical properties of the aluminum alloys are summarized for some common structural aluminum 5000 series alloy in Tables XIII and XIV. In summary, alloys 5086 and 5083 are recommended for the major structural components of the crane, such as girders, end ties and trolleys.

The alternate alloy group, the 6000 series alloys, is very readily heat-treatable due to the presence of magnesium-silicon metallic compounding that alters its crystalline shape under solution heat-treatment. Common practice is to furnish the alloy in the T6 temper. This involves heating the alloy followed by a rapid quench fixing the grain structure and further artificial aging to precipitate the magnesium-silicide. It is significant to note that magnesium-silicon heat-treatment can be accomplished quite well by quenching in air. Thus, it is possible to obtain a heat-treated effect in the heat affected zone of a weld due to the rapid self-quenching by the aluminum mass. Because of this effect, reasonable strengths in welding can be obtained. On the other hand, if the material were fully annealed and cooled slowly, such as by applying a torch for an extensive period of time, the material will anneal to a dead soft condition having very poor strength. Special care in design stress selection for 6000 series alloys is very important, and conservative practices must lean toward possible full annealing.

Perhaps the only drawback of the use of 6000 series alloys in major crane fabrication is that the welds can vary considerably in properties. A rapid weld produces highest strength but not too much ductility. Lack of ductility is an indicator of lowered shock or impact resistance. A slow speed weld will improve ductility, but the annealing effect severely reduces the joint strength to levels that cannot be accepted.

TABLE VI
Crane Specifications For Example 105-ft Span Two-Block Overhead Traveling Crane At Kaiser Aluminum Rolling Mill in Ravenswood, W. Va.

Item		
Lift Capacity	50-Ton, two 25-ton blocks	
Span	105 ft-0 in.	
Lift	30 ft-0 in.	
Full load travel speeds		
Hoist, fpm	30	
Trolley, fpm	150	
Bridge, fpm	300	
Travel motor sizes	**Aluminum construction**	**Steel construction**
Hoist, hp	135	135
Trolley, hp	19	33
Bridge, hp	two 45	two 65
Weights		
Per wheel load, lb	52,200	71,500
Girders (two), lb	61,000	135,000
Walks, total, lb	9,300	24,000
Conductor, conduit, cabinets, lb	3,300	10,000
Gear cases, lb	2,500	7,000
Trolley, lb	10,000	23,000
End ties, lb	5,100	15,000
Trucks and bumper, lb	6,000	15,000
Cab, lb	2,200	4,500
Auxiliary girder, lb	...	10,000
Remainder,* lb	...	...
Structural components, lb.	99,400	243,500
Total girder weight, including walks and equipment, lb	124,000	251,500
Total trolley weight, lb	46,500	60,000
Total crane weight, lb	170,500	311,500
Wheels		
Number	8	8
Size, diam, in.	24	24
Wheel load capacity, lb	67,000 on 105-lb rail	89,000 on 135-lb rail

* Remainder includes mechanical and electrical equipment, wheels and rails common to both cranes.

The 6000 series alloys are not recommended for the main structural components of cranes such as girders, end ties, and trolley frames. However, the wide availability of structural shapes, pipe, sheet, plate and specialty items plus the satisfactory welded strength provide a basis for recommendation of these alloys for secondary structural components such as walks, trolley trim, cabs, gear cases, etc. All 5000 and 6000 series alloys are compatible with one another for welding and corrosion resistance and may be interchangeably used where structural limits allow.

DESIGN DETAILS

Structural designing with aluminum will follow the usual pattern of metal stress analysis. Standard equations for bending, shear and axial stresses apply independently to the material.

Further evaluation of aluminum crane design can be more readily reviewed by selecting a specific crane design and following the application of the design.

For the example, consider a 50-ton (consisting of two 25-ton blocks) capacity 105 ft span aluminum bridge crane installed in the Kaiser Aluminum rolling mill at Ravenswood, W. Va. The outline crane specifications are as shown in Table VI, and Figure 4 shows the actual installed product.

The girder is singled out as a specific example stress application because it requires, in successive steps, evaluation of applied loads and their resulting moments and shears; assumption of girder and trolley weights for dead load moment and shear determination; evaluation of girder properties; determination of tensile, compressive, and shear stresses; deflection analysis; and diaphragm determination and evaluation. The AISE Standard No. 6 allowable stresses with suggested modification for aluminum alloys, shown in Table VII, are the basis for stress evaluation.

Table VIII is a summary of calculated stress levels for the aluminum girder related to the suggested allowable conditions of the AISE Standard. This includes the first approximation outline calculations for determination of the structural configuration of aluminum and steel girders for the example 50-ton, 105-ft span crane. Figure 5 represents a schematic showing the general girder configuration outlining applicable dimensions and characteristics of design, and Figure 6 shows the actual assembled girder prior to erection.

Review of buckling analysis procedures are desirable as the material selection does have some influence on design levels. The basic form of the buckling equations for axially loaded columns is:

$$S = \frac{\pi^2 E}{\frac{(KL)^2}{r}} \qquad (5)$$

where

E = modulus of elasticity of material
K = column end fixity factor
L = effective length of column under compression
r = radius of gyration of column

Variations from the basic form of the buckling equation may be applied to plate compression, web shear, web bending compression, and outstanding legs under compression. The influence of the lower modulus of elasticity of aluminum will result in buckling stress levels approximately one-third of steel levels at high slenderness ratios. As the slenderness ratio decreases, the form of the buckling equation changes as the "E" term becomes the tangent modulus and begins to decrease. This is the intermediate column region, and usual practice is to approximate this range with a modified linear equation of the form

$$S = B - C\left(\frac{KL}{r}\right) \qquad (6)$$

Equations 5 and 6 are shown for the applicable alloys in Figures 14 and 15. Both the AISE and EOCI codes have buckling design limits for cover plates, flange legs, webs, longitudinal web stiffeners, transverse web stiffeners or diaphragms, all based upon the basic form of the buckling equations. Aluminum design will use the same form of equations but with constants reduced as required by the ratio of modulus of elasticities.

The design of aluminum and steel produces several limit conditions of note. First, the maximum vertical bending stresses in both girders are limited by the maximum deflection limits. In fact, the long span adds such a high dead load deflection that the EOCI Code will pose more severe restrictions on design. The second design limit occurs on the webs acting as flanges under lateral load. This is particularly critical for aluminum with the design example producing an equivalent KL/r of 277 and a safety factor of 1.72. The design showed full diaphragms were required for web buckling and intermediate partial diaphragms were required for crane rail support. Web longitudinal stiffening was also required.

Stress analysis of the girder, then the end ties, trolley, walks, cab and gear cases will require calculation of axial and bending stresses and shear and bearing similar to the application of mild or high tensile steels. Aluminum has significantly high bearing strength but reduced shear levels which might be taken advantage of in design. Generally, however, the design intent will stay constant, independent of material.

Shock and impact loading on cranes can frequently represent high multiplying factors in compounding total stress. Aluminum has considerable impact absorption capacity, because of the ability of aluminum to deflect and by so doing absorb, locally and in total, high energies. The effect of vibration is minimized by the energy absorption levels. Energy absorption capacity will also include considerations of fatigue. Although the fatigue levels are moderate, they still provide ample safety factor for aluminum structures in crane usage.

Connectors for aluminum crane structures can be handled readily with existing available bolts, nuts and rivets. It is strongly recommended that turned or reamed holes be used wherever possible to take advantage of higher allowable bearing stresses. Normally, the design limitation for bolts is the shear of the bolt using gages and sizes common to the structural field. However, bearing limits must be evaluated.

Aluminum is a highly satisfactory bearing material for use on sleeve bearings on all cranes. It has been used successfully for many years in slow moving centrifugal and reciprocating machinery, such as compressors, tractor, diesel engines, railroad cars and cranes. The most satisfactory aluminum alloys, generally containing small percentages of tin and/or lead, will sustain bearing pressures in excess of 5000 psi. However, for the designer preparing an aluminum crane, the more common casting alloys, such as 43, 356, or 214, can be used successfully at lower bearing pressures and relatively slow speeds within the ranges common to crane applications. Should the designer wish to include wrought alloys, it is suggested that 1100, 5005, or 5052 be utilized in this application. Pressure lubrication must be designed into all aluminum bearings. The advantage of an aluminum bearing in connection with an aluminum structure is uniformity.

FABRICATION

The fabrication of aluminum cranes will involve no new concepts, but will require the fabricator to modify his normal quality control and inspection procedures.

Fundamentally, aluminum is cut, formed, machined, and welded in a manner similar to steel; but identical practices cannot be used due to the peculiarities of the various physical and thermal properties of the metal. In order to present a picture of what this represents, the fabrication sequence will be discussed in separate parts.

Receiving and storing of aluminum metal should probably be discussed first. Aluminum plate is furnished in what is referred to as a mill finish. It tends to be of a pronounced gray color. The material is normally oil-free and ready for fabrication upon receipt. If the material is to be retained in storage for an appreciable period of time, it is recommended that the crates be opened and the material stored to allow air circulation between surfaces. This will prevent the development of water stains on the surface of the material. These water stains have no structural effect but do distract from the appearance of the finished product.

The material may be cut to shape in one of several methods. The use of saws is probably the most common method. The power requirements and techniques of sawing aluminum might be compared to a combination of sawing hardwood and mild steel. Aluminum will saw very readily up through 3-in. thicknesses by the use of either a portable saw or a fixed band or table saw. Figure 7 shows the sawing process on a 3-in. 5083 plate. The cautions to be observed during the sawing process include high surface cutting speeds coupled with large clearance angles. As the aluminum chips tend to pick up heat and become soft quite readily, it is absolutely necessary that the chips be removed cleanly and rapidly to prevent sticking and welding of blades. Therefore, it is common practice to recommend saws that will produce at least 1000 sfpm cutting speeds. In addition, it is desirable to have high horsepower motors to prevent stalling while cutting. Stalling will allow time for the aluminum to heat and become soft thus making it impractical to continue the cut until the metal is cooled.

An alternate method of cutting, which is readily adapted to the $\frac{1}{4}$ to $1\frac{1}{2}$-in. thickness range, is atomic hydrogen inert gas cutting. This system cuts at extremely high speeds and is adaptable to complex shapes in a manner similar to conventional flame-cutting of steel. The finish surfaces of both the sawed and torch-cut material are satisfactory for welding.

Aluminum may be formed or shaped readily. The effect of parent material strain hardening must be considered at this point. Since all the aluminum alloys under discussion have some limit to formability, it is necessary to use caution in the selection of bend radii to avoid, first, edge cracking, followed by complete fracture. It should be noted, however, that edge cracking on a tight radius bend is not entirely detrimental and can be readily repaired by welding without danger of crack propagation beyond this point. Recommended

TABLE VII
Specification Requirements for Girders Based on AISE Standard No. 6

Item No.	ASTM A-7 steel	Suggested aluminum design values	
		5083-H113	5086-H112
17 G-			
1. Minimum ultimate tensile strength, psi	60,000	44,000	36,000
2. Minimum yield point, psi	33,000	31,000	18,000
3. Unit stress in tension on net section not to exceed psi	18,000	9,500	8,750
4. L/B not to exceed:			
a. Riveted box girders	65	...	...
b. Welded box girders	60	60	60
5. Compressive unit stresses in psi for top flange of box girders; when b/t is less than:	40	30	20
either	17,000	9,500	8,750
or	$\frac{0.673E\sqrt{I_2J}}{ZL}$	$\frac{0.673E\sqrt{I_2J}}{ZL}$	$\frac{0.673\sqrt{I_2J}}{ZL}$
6. Compressive unit stresses in psi for top flange of box girder when b/t is greater than	40	30	20
	$27{,}200{,}000\left(\frac{t}{b}\right)^2$	$13{,}000 - 108\left(\frac{b}{t}\right)$	$10{,}300 - 80\left(\frac{b}{t}\right)$
7. Compressive unit stresses in psi for axially loaded columns and struts shall not exceed	$15{,}000 - 0.25\left(\frac{L}{r}\right)^2$	9,500 for $\frac{KL}{r} < 42$	8,750 for $\frac{KL}{r} < 28$
		$13{,}000 - 77\left(\frac{KL}{r}\right)$ for $\frac{KL}{r} > 42$	$10{,}300 - 57\left(\frac{KL}{r}\right)$ for $\frac{KL}{r} > 28$
8. L/R for azially loaded columns and struts shall not exceed	120	120	120
9. Maximum allowable unit shear (S) in web plates, psi	12,000	5940	5460
10. Unless vertical stiffeners are used h/t shall not exceed, psi	6600	3930	3930
	$\sqrt{S_s}$	$\sqrt{S_s}$	$\sqrt{S_s}$
11. Spacing of vertical stiffeners in inches when required by the foregoing shall not exceed, psi	$\frac{10500\ t}{\sqrt{S_s}}$	$\frac{6250\ t}{\sqrt{S_s}}$	$\frac{6250\ t}{\sqrt{S_s}}$
12. Unless longitudinal stiffeners are used h/t_w shall not exceed	$72(K+1)\sqrt{\frac{17{,}000}{S_c}}$	$50(K+1)\sqrt{\frac{9500}{S_c}}$	$C_1(K+1)\sqrt{\frac{8.750}{S_c}}$ H32 temper, $C_1 = 50$ H112 temper, $C_1 = 25$
13. If h/t exceeds ratios given by 17-G-12, the webs must be stiffened with adequate and sufficient longitudinal stiffeners. When one longitudinal stiffener is used and placed as specified, (17-G-23), the maximum h/t ratio may be doubled. When two longitudinal stiffeners are used and placed as specified, (17-G-23), the maximum h/t ratio may be tripled.			

TABLE VII (Continued)

	For ASTM A-141 steel	2024-T4	
14. Shearing:			
a. Rivets, psi	13,500	12,000	
b. Pins and turned bolts in reamed or drilled holes, psi	13,500	12,000	
c. Unfinished bolts, psi	9,000	8,000	
15. Bearing:			
a. Rivets in single shear on:			
1. Carbon steel, psi	24,000	24,000	
2. High tensile steels, psi	24,000	24,000	
3. 5083-H113, psi	15,000	15,000	
4. 5086-H112, psi	14,000	14,000	
b. Rivets in double shear on:			
1. Carbon steel, psi	30,000	27,000	
2. High tensile steel, psi	30,000	27,000	
3. 5083-H113, psi	19,000	19,000	
4. 5086-H112, psi	17,000	17,000	
5. Pinned and turned bolts in reamed or drilled holes, psi	30,000	27,000	
6. Unfinished bolts, psi	16,000	16,000	
	For ASTM A-7 steel	**5083-H113**	**5086-H112**
17. The bearing stress of parts in contact such as stiffeners and flange plates shall not exceed			
for milled surfaces, psi	27,000	19,000	17,500
for unfinished surfaces, psi	24,000	12,700	11,700
18. For stress carrying members, the spaces between intermittent welds shall be not greater than 10 times the thickness of the lighter section joined by the welds for members in compression, nor more than 14 times the thickness of the lighter section for members in tension. The length of any segment of intermittent weld shall be not less than 4 times the weld size with a minimum of 2 in.			
19. Rivets shall be spaced not more than 16 times the thickness of the lighter outside section, or more than 6 in. on centers.			
20. The width of outstanding legs in compression shall not exceed	$12t\sqrt{\frac{17{,}000}{S_c}}$	$9t\sqrt{\frac{9500}{S_c}}$	$6t\sqrt{\frac{8750}{S_c}}$
21. or a maximum for outstanding legs of	16t	13t	13t
22. and also for cover plates, in.	6	5	5
23. When one longitudinal stiffener is used on girder webs, it shall be placed 21 per cent of the clear depth of the web from the unstiffened compression edge. When two longitudinal stiffeners are used, these distances are 12.5 per cent and 28 per cent of the clear depth of the web from the unstiffened compression edge.			
24. The required radii of gyration of horizontal stiffeners are to be computed from the formula in Table 17-VI with the appropriate constant selected from the table.			

Values of Stiffener Coefficient (Table 17-VI of AISE Standard No. 6)

	Values of C, for the following values of web thickness, T, in inches					
	5/16	3/8	7/16	1/2	9/16	5/8
Riveted steel—one stiffener	1.07	1.37	1.67	1.99	2.29	2.64
Riveted steel—two stiffeners	0.59	0.73	0.87	1.02	1.17	1.33
Welded steel—one stiffener	1.14	1.46	1.79	2.13	2.48	2.84
Welded steel—two stiffeners	0.65	0.80	0.95	1.11	1.27	1.44
Riveted aluminum—one stiffener	2.45	3.15	3.85	4.55	5.22	5.90
Riveted aluminum—two stiffeners	1.31	1.66	2.01	2.36	2.67	2.98
Welded aluminum—one stiffener	2.70	3.46	4.23	5.00	5.74	6.48
Welded aluminum—two stiffeners	1.44	1.82	2.21	2.60	2.93	3.28

28. Metal shall not be less than 5/16 in. thick for classification ASTM A-7 steel, or 1/4 in. for high tensile steel, or 5083 and 5086 aluminum. The remaining items apply to aluminum without change.

Notation used in formulae:

- L = span of crane in inches.
- b = distance between webs in inches.
- t = thickness of web or flange in inches.
- h = clear depth of web, toe to toe of vertical legs of flange angles for riveted construction and back to back of cover plates for welded construction in inches.
- S_s = unit shear in web plates in psi.
- r = radius of gyration in inches.
- S_c = maximum compressive stress in member considered in psi.
- S_t = tension stress acting concurrently with S_c in member in psi.
- K = S_t/S_c.
- Z = vertical section modulus in inches.[3]
- E = modulus of elasticity in psi.
- I_2 = moment of inertia of whole girder section about vertical axis in inches.[4]
- J = torsional constant in inches.[4]
- B = clear width of top flange, distance between inside rivets for riveted construction and distance between webs for welded construction in inches.

For explanation of symbols see Figure 5.

TABLE VIII
Example 50-Ton, 105-ft Span Girder Design Data

Girder estimate	Aluminum	Steel
Section		
Top flange, in. x in.	1 x 40	$\frac{7}{8}$ x 38
Webs (two)	$\frac{3}{8}$ x 94	$\frac{3}{8}$ x 76
Bottom flange, in.	1 x 40	$\frac{7}{8}$ x 38
Total depth, in.	96	77.75
Moment of inertia, X axis, in.^{4}	232,400	125,400
Section modulus, X axis, in.^{3}	4,850	3,240
Moment of inertia, Y axis, in.^{4}	31,880	26,440
Section modulus, Y axis, in.^{3}	1,821	1,470
L/H ratio (18.0 maximum)	13.1	16.2
Girder weight estimate, structure only, lb	23,228	53,610
Static bending moment, lb-in.	28,235,000	37,919,000
Maximum dynamic bending moment, lb-in.	31,175,000	40,859,000
Maximum lateral bending moment, lb-in.	1,412,000	1,896,000
Shear at girder end, lb	95,500	128,600
Shear at maximum moment, lb	42,300	48,900
Calculated Stresses		
Maximum bending stress		
Tension, psi	+6,430	+12,600
Compression, psi	−6,430	−12,600
Maximum lateral bending stress, compression, psi	780	1,290
Shear at girder end, psi	3,850	5,290
Shear at maximum bending, psi	600	1,020
Bearing, rail under diaphragm, psi	13,900	27,800
Deflections, Code		
AISE, Std No. 6, 1949 0.0010 L-in. Lift load + trolley	1.26	1.26
EOCI Spec No. 49, 1949 0.00125L-in. Lift load + trolley + dead load	1.57	1.57
Deflections, Calculated		
Lift load + trolley, in.	1.27	0.92
Dead load, in.	0.46	0.65
Total deflection, in.	1.73	1.57
Diaphragms		
h/t_w	250	202
Longitudinal stiffeners	Yes	Yes
Maximum spacing, vertical stiffeners, in.	63.5	76.0
Maximum spacing, rail support diaphragm, in.	31.2	34.0
Ratio of aluminum to steel girder structural weight	0.434	

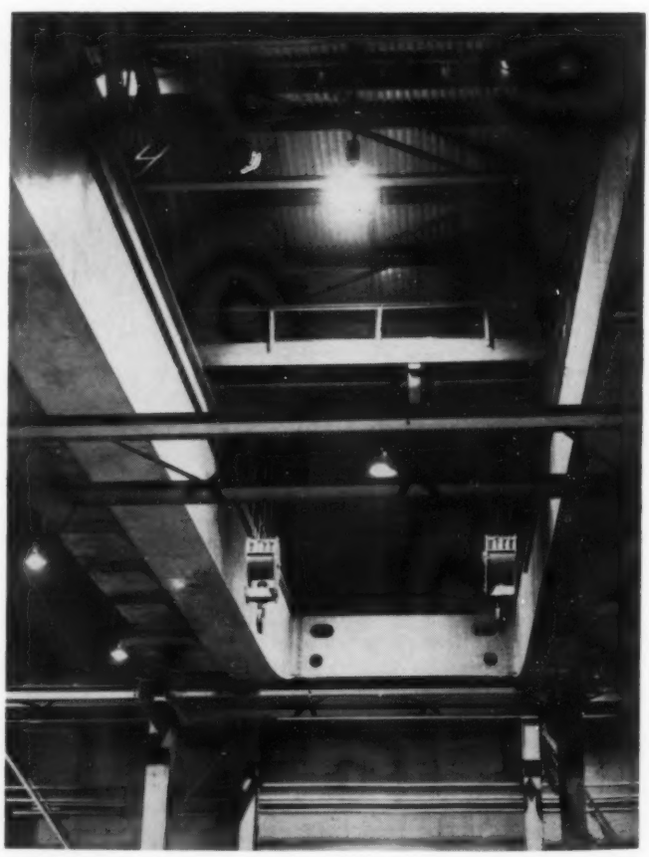
minimum 90-degree bend radii are listed with each alloy in the charts.

Aluminum alloys are readily machinable by milling, grinding, planing and drilling. The 5000 series alloys, or the high magnesium alloys, tend to work harden rapidly. Consequently it is recommended that surface cuts be made with authority. This is interpreted to avoid very light cuts tending to work harden the material. Speed is very important in this phase of production as the chips must be removed rapidly to prevent sticking. This would be particularly true in confined machining such as drilling where the chips require a finite period of time to advance up the flutes and clear the work. It is recommended that a coolant be considered where the time for producing the hole exceeds 10 sec, as the loose chips retained about the work will have sufficient time to accumulate and soften. Water and a very light soluble oil have been used satisfactorily for this application. Figure 8 shows a completed trolley structure on the vertical machining ways of a large crane manufacturer.

Aluminum may be machined easily with a variety of portable tools, much like hardwood. It may be planed, sawed, ground, chipped, drilled and reamed by hand tools. The emergence of the inert-gas-shielded arc process of welding applied to aluminum has provided the major basis of economic feasibility for aluminum cranes. This method of welding is based on a shield envelope gas flow of argon and/or helium to provide an inert, oxygen-free envelope surrounding the electrode and molten weld pool. This shield prevents the combination of aluminum and oxygen in the molten state, insuring sound high strength welds. The cone of the welding gun may be equipped with either a non-consumable tungsten electrode (TIG) requiring external feeding of welding wire or a continuous feed of filler wire through the center of the gun which doubles as the electrode (MIG). Power sources are high frequency alternating current for the tungsten electrode and direct current for the consumable electrode. Cooling water is required for the larger models of both guns. Figure 9 shows the MIG welding equipment being used on a crane structure. Attention is directed to the drive unit containing a 10-lb spool of $\frac{1}{16}$-in. diam, alloy 5356 filler wire which is forced through the gun for deposition in the weld pool.

Insofar as the crane manufacturer is concerned, the bulk of his fabrication will be through the consumable electrode (MIG) method. Weld speeds of 24-in. per min. per pass can be anticipated for manual welding. The normal heat rate for aluminum welding is approximately 100,000 amp per sq in. of electrode, using approximately 27-v, d-c power output. By contrast, the tungsten arc (TIG) gun has current densities of 10–20,000

Figure 4 — This 105-ft span aluminum overhead traveling crane, consisting of two 25-ton blocks, is installed in the Kaiser Aluminum rolling mill at Ravenswood, W. Va.



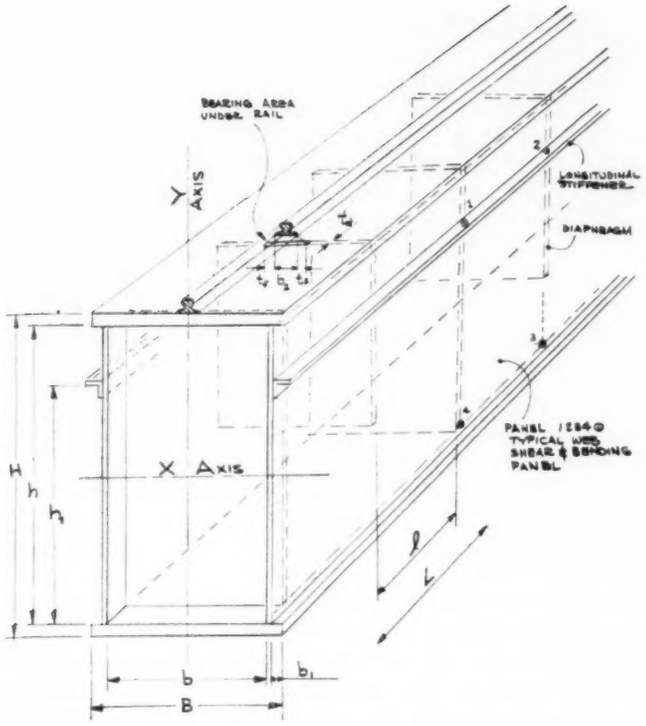


Figure 5 — This outline schematic shows the typical configuration of the bridge beam of a traveling overhead crane.

amp per sq in. of electrode, and welding speeds are of the general order of ¼ to ½ of the consumable electrode speeds. Nevertheless, the tungsten electrode system is commonly used for light gage weldments, repair work, and some confined space welding.

Confining the discussion of welding to the recommended alloys for crane applications, one must make specific note of the alloying effect of three elements. Copper rich alloys are unacceptable for structural weldments due to the formation of a very brittle metallurgical structure in and adjacent to the welds. Magnesium, a recommended alloying element (common to all 5000 series alloys), produces high strength, ductile welds. Silicon is used sparingly in crane structure applications as it tends toward brittleness and poor shock resistance in welds. The presence of both magnesium and silicon produces a weldable heat-treatable alloy of high strength until the combined total of the magnesium and silicon reaches 1.6 per cent (common to 6000 series alloys). Beyond this percentage magnesium silicide has exceeded maximum solubility and will produce welds with brittleness increasing with percentage. Therefore, it is recommended that special care be given in designing to avoid the mixing of excesses of magnesium (greater than 1 per cent) and silicon (greater than 0.6 per cent) to prevent brittleness.

The major structural elements should be 5000 class alloys, and recommended welding wire for these weldments is 5183 or 5356. The 6000 series alloys are compatible with the 5000 series and are recommended for secondary structural components where stress and shock levels are moderate. The only place where the designer may encounter silicon-rich alloys is in castings since many common casting alloys that might be used in the structural field have substantial quantities of silicon to improve casting properties. The welding of these silicon-rich castings to the 5000 series structural system is not recommended except in zones of very low stress and nominal shock conditions. High silicon castings may be welded satisfactorily to 6000 alloys with 4043 wire. However, in the interest of avoiding mixing magnesium and silicon welding wires and weldments with unpleasant results, it is recommended that the 4043 wire be excluded from the structural design system.

Weld preparation must be emphasized to ensure sound welds being produced by the average qualified welder. Porosity and low strength welds are due generally to the

Figure 6 — This is the bridge of the crane shown in Figure 4 prior to erection.

Figure 7 — Sawing aluminum requires a minimum saw speed of 1000 fpm and sufficient horsepower to insure against stalling.

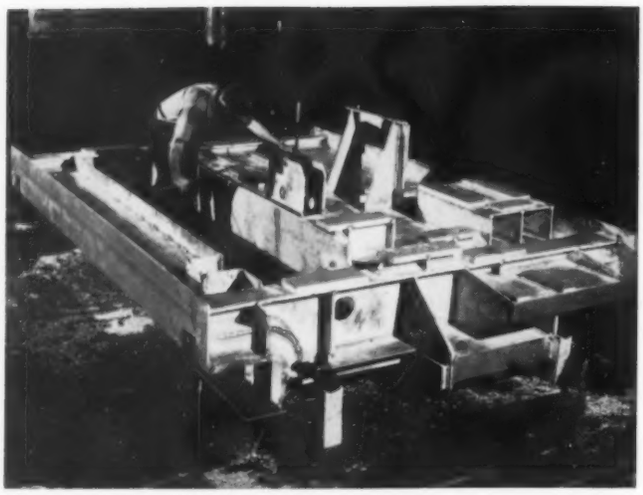


Figure 8 — Completed aluminum trolley.

presence of excessive quantities of aluminum oxide or dissolved hydrogen that gassifies during the cooling cycle. Therefore, weld cleanliness must include all useful means of eliminating all hydrogen and most aluminum oxide from the prepared surfaces. Aluminum oxide can usually be held under control by brushing prior to welding except where a piece of material has been allowed to weather and build up a heavy oxide coating. In this limited case a caustic wash would be helpful followed by brushing. Hydrogen is present in water or hydrocarbons such as oil or grease. Hence, surfaces must be free of all moisture, greases and oils prior to welding. Normal precautions, such as elimination of oily rags and gloves and a clean environment, will usually be sufficient. Where oil and grease have accumulated, a solvent may be used for removal. Pre-weld cleaning must be thorough but not extraordinary, and the experienced welder can usually "feel" his own required level of cleanliness.

Distortion of aluminum weldments is a necessary consideration to the crane designer. Depending upon the type of structure, position, sequence, and degree of restraint, a weldment distortion can be minimized. Sequence experiences in steel welding are generally applicable to aluminum welding. However, some generalized comments might be useful to the designer.

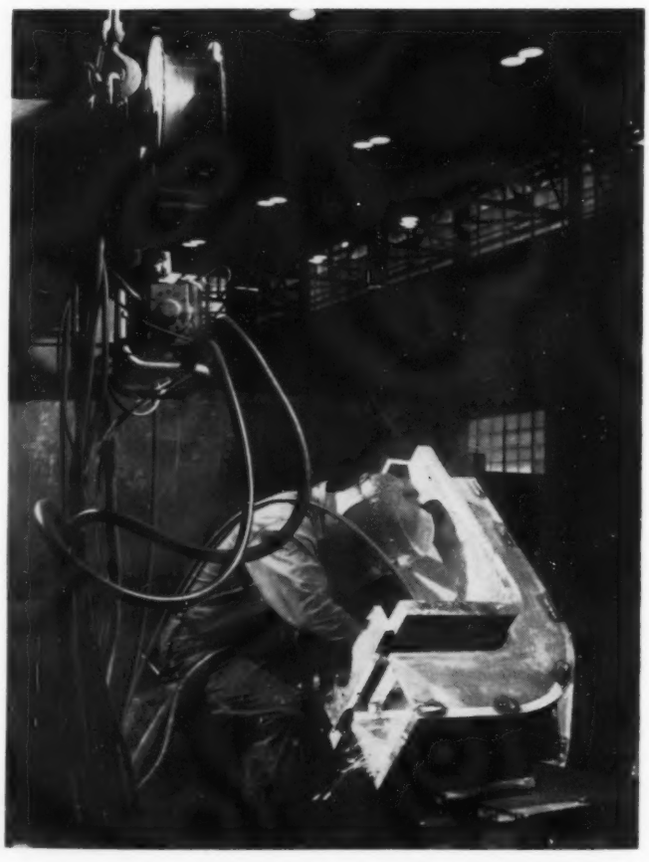
Unrestrained aluminum welding will cause growth of structures under the application of heat, particularly in long welds where there is opportunity to store large quantities of heat in the metal mass. Even though the aluminum may expand considerably during the welding process, the residual stresses developed are generally quite low due to the lower modulus of elasticity. Consequently, it usually is advantageous for the welder to restrain his structure and weld toward restraint. Simultaneous welding about symmetrical axes is highly recommended. Machine welding over long distances can readily be accomplished if proper jigging has been done. For example, consider the welding of the main girder, Figure 10, as a case for control of distortion. The weld distortion of the finished girder was negligible laterally and ½ in. vertically, reducing the preset camber to 1 in. for a 105 ft-0 in. span. The accepted sequence of welding consisted of:

1. Fix top flange to floor with desired preset camber (1½ in.).
2. Tack diaphragms to top flange.
3. Tack diaphragms to first web plate.
4. Finish weld diaphragms to top cover (distortion of diaphragm and flange restrained by web and floor respectively).
5. Tack second web plate to diaphragms.
6. Turn girder to side and finish weld diaphragms to webs (permits down hand welding, distortion is restrained by the top flange and the symmetry of the structure).
7. Tack bottom flange to webs.
8. Continuous weld webs and top flange simultaneously (vertical distortion restrained by webs, lateral distortion controlled by simultaneous action and symmetry).
9. Continuous weld webs and bottom flange simultaneously.
10. Weld web butt joints.

Finally, in considering aluminum welding, questions affecting weld length and fit-up must be considered. Since the heat will expand and distort aluminum more rapidly than steel, a close fit for aluminum alloys is recommended. Where butt welds are to be made, a steel or copper backup chill bar is desirable. Experience has shown that in the consumable electrode (MIG) welding system, minimum weld length should be of the order of 2 to 3 in. The AISE Standard allows two-in. min. This allows ½ in. for the lower strength of the cold start-up and the possibility of a shrinkage pool in the last ½ in. plus time to obtain full penetration and strength in the remaining weld length.

Generally it has been found by leading fabricators that the cost of fabrication of aluminum is equal to or

Figure 9 — Aluminum cranes were made feasible by the development of the inert gas, shielded arc welding process.



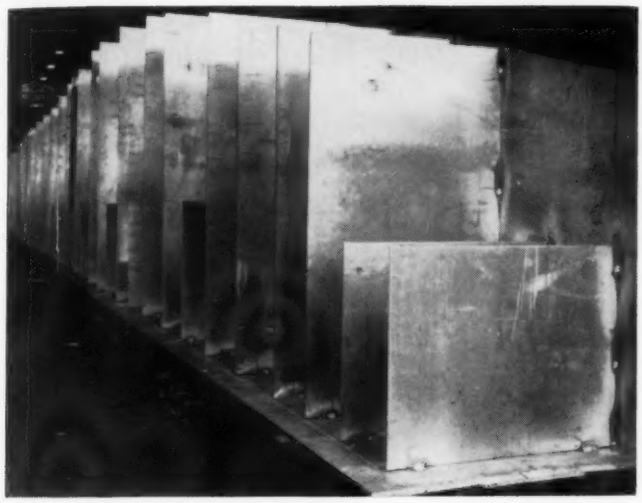


Figure 10 — The weld distortion of the finished 105-ft girder was negligible laterally and ½ in. vertically.

slightly higher than comparable steel structures. Aluminum gains in handling, cutting, machining, and welding speeds, saving considerable man-hours of construction time; but losses occur on gas and welding wire cost, fit-up time, and scrap allowances.

For a preliminary estimate, assume the labor cost of aluminum to be 10 per cent higher than an equal steel job. A simplified fabrication breakdown is shown in Table IX. The $28,800 premium for aluminum will be reduced by cost of electrics and foundations, freight and erection to produce a final comparison shown later.

POWER EQUIPMENT AND ELECTRICS

The reduction of dead load structure weight on the aluminum cranes will allow some decrease in the size of electric machinery. Selection of this equipment is a compromise between maximum starting torque and maximum running horsepower. Starting torque will govern the rate of acceleration of the crane components while the maximum horsepower will govern maximum free-running velocity.

In regards to the acceleration portion of the crane bridge and trolley, the power requirements are a combination of acceleration force and velocity of those parts in rotation and those in translation. The forces can be expressed by:

$$\text{F Rotation} = I\frac{\alpha}{r}$$

$$\text{F Linear} = \frac{W}{g}a$$

where:

- I = total mass moment of inertia of all rotating wheels, lb-ft sec^2
- W = total weight of structure and load, lb
- α = angular acceleration of rotating parts, rad per sec^2
- a = linear acceleration of weight, ft per sec^2
- r = radius of wheels, ft
- α = a/r
- g = gravity = 32.2 ft per sec^2

Total force is expressed as:

$$F_T = F_R + F_L = \left[\frac{I}{r^2} + \frac{W}{g}\right]a$$

In almost all cases the rotating inertia of the wheels $\frac{I}{r^2}a$ can be neglected as small compared with the linear inertia effect $\frac{W}{g}$ a. The acceleration horsepower is expressed as:

$$HP_a = F_T V/550e$$

where

- V = velocity at any time, fps
- e = drive efficiency of motor and gearing

Desired acceleration will vary from a maximum at low running speeds to a substantially lower value when the structure is operating near its terminal velocity. At terminal velocities the acceleration horsepower represents the motion reserve. The maximum acceleration will average about 1.5 ft per sec^2, and terminal acceleration normally is considered as 20 to 40 per cent of the maximum. Full acceleration will be cut back by the controls during the last third or quarter of the cycle. This is a compromise to obtain realistic motor sizing.

The free running horsepower required to maintain the structure and load at terminal velocity is:

$HP_f = fWV/550e$

where: f = friction factor, lb of friction per lb of normal load.

The friction factor is conditional upon the type of bearings in the system. It is normally assumed as 0.0075 for roller bearings and 0.012 for sleeve bearings.

The total horsepower capacity of the drive motors for the bridge and trolley must be a combination of the free running horsepower (HP_f) and the acceleration capacity (HP_a) at terminal velocity. Consider now a specific comparison of the 50-ton steel crane of Table VI to one constructed of aluminum.

Example:

Capacity	50 tons	
Span	105 ft-0 in.	
Wheels, eight @ 24 in. diam		
	Aluminum	Steel
Rail size, lb per yard	105.0	135.0
Inertia, I, for eight wheels, lb-ft sec^2	34.0	34.0
Total crane dead weight, lb	170,500	311,500
Total weight and load, lb	270,500	411,500

TABLE IX

Comparative Costs of Aluminum and Steel Structures For Crane Specified in Table VI

Construction material	Aluminum	Steel
Gross weight, structures, lb	99,400	243,500
Unit costs per lb of material, fob shop		
Material	$0.49*	$0.08*
Fabrication	0.51	0.19
Extra painting & finishing	...	0.02
Total cost per lb of fabricated material	$1.00	$0.29
Gross structure costs	$99,400	$70,600
Premium for aluminum crane	$28,800	
Ratio of aluminum to steel crane weights	0.41	
Ratio of aluminum to steel crane costs	1.40	

* Consisting of 12-per cent structural shapes and miscellaneous metal work and 88-per cent plate.

BRIDGE GIRDER DRIVE

For computation assumed for bridge
Maximum acceleration = 1.5 ft per sec²
Terminal acceleration = 0.4 ft per sec²
Terminal velocity = 300 fpm or 5.0 ft per sec
Assumed motor and gear train efficiency = 0.70
Assumed friction factor (sleeve bearings) = 0.012

Aluminum Crane

$$F_T \text{ maximum at start} = \left[\frac{34.0}{1.0^2} + \frac{270{,}500}{32.2}\right] 1.5 = 12{,}600 \text{ lb}$$

$$F_T \text{ terminal} = \left[\frac{34.0}{1.0^2} + \frac{270{,}500}{32.2}\right] 0.4 = 3360 \text{ lb}$$

$$HP_a = \frac{F_T V}{550e} = \frac{(3360)(5.0)}{550(0.70)} = 43.7 \text{ hp}$$

$$HP_f = \frac{fWV}{550e} = \frac{(0.012)(270{,}500)(5)}{550(0.7)} = 42.2 \text{ hp}$$

Total required horsepower for girder drive 85.9 hp

Steel Crane

$$F_T \text{ max} = \left[\frac{34.0}{1.0^2} + \frac{411{,}500}{32.2}\right] 1.5 = 19{,}200 \text{ lb}$$

$$F_T \text{ terminal} = \left[\frac{34.0}{1.0^2} + \frac{411{,}500}{32.2}\right] 0.4 = 5120 \text{ lb}$$

$$HP_a = \frac{(5120)(5.0)}{550(0.7)} = 66.6 \text{ hp}$$

$$HP_f = \frac{(0.012)(411{,}500)(5.0)}{550(0.7)} = 64.1 \text{ hp}$$

Total required horsepower for girder drive 130.7 hp

As a means of further comparison, the empirical minimum horsepower equation recommended by the AISE is:

$$HP = KaWV$$

where:

Ka = factor that depends on friction and acceleration
W = total weight of structure and load, tons
V = terminal velocity, fpm

Ka is determined from curve 43-1 of the AISE Standard. The terminal power, velocity and acceleration conditions assumed allow for an acceleration horsepower excess of about 40 to 45 per cent above the free running horsepower requirements. Terminal accelerations will be much lower than in the previous example where acceleration horsepowers added 100 per cent to free-running horsepower. In the specific examples shown these values would be:

Aluminum Crane Construction

$$HP = (0.00148)\left(\frac{270{,}500}{2{,}000}\right)(300) = 60$$

or from previous calculation using the constant
$HP_f = 42.2$ and by subtraction
$HP_a = 17.8$ or 42.4 per cent of HP_f
Terminal acceleration = 0.165 ft per sec²

Steel Crane Construction

$$HP = (0.00148)\left(\frac{411{,}500}{2{,}000}\right)(300) = 91.5$$

or from previous calculation
$HP_f = 64.1$ and by subtraction
$HP_a = 27.4$ or 42.6 per cent of HP_f
Terminal acceleration = 0.165 ft per sec²

Based on the first calculations, the selected drive motor sizes for the two cranes would be:

Aluminum	two @ 45 hp	=	90 hp
Steel	two @ 65 hp	=	130 hp

In the particular case of the aluminum crane, two 100-hp d-c motors were connected in series to produce required power at a savings in control equipment requirements. However, for comparison purposes, the motor sizing above may be considered. The assumed drives are based on standard d-c mill and shovel motors.

TROLLEY DRIVE

The trolley will also require less horsepower for the aluminum structure. However, the magnitude of the reduction will be smaller than for the bridge as the effect of dead weight is much lower. If the previous examples are referred to and the inertia effect of the wheels is neglected, the following results are obtained.

Capacity = 50 Tons = 100,000

	Aluminum	Steel
Trolley weight, lb	46,500	60,000
Total weight with load, lb	146,500	160,000

Maximum acceleration = 1.0 ft per sec²
Terminal acceleration = 0.25 ft per sec²
Terminal velocity = 150 fpm = 2.5 ft per sec
Assumed efficiency = 0.70
Assumed friction factor = 0.012

Aluminum Trolley Construction

$$F_T \text{ max} = \frac{(146{,}500)(1.0)}{32.2} = 4550 \text{ lb}$$

$$F_T \text{ terminal} = \frac{(146{,}500)(0.25)}{32.2} = 1137 \text{ lb}$$

$$HP_a = \frac{(1137)(2.5)}{(550)(0.70)} = 7.38 \text{ hp}$$

$$HP_f = \frac{(0.012)(146{,}500)(2.5)}{(550)(0.70)} = 11.42 \text{ hp}$$

Total required horsepower for trolley drive 18.80 hp

Steel Trolley Construction

$$F_T \text{ maximum} = \frac{(160{,}000)(1.0)}{32.2} = 4970 \text{ lb}$$

$$F_T \text{ terminal} = \frac{(160{,}000)(0.25)}{32.2} = 1240 \text{ lb}$$

$$HP_a = \frac{(1240)(2.5)}{(550)(0.70)} = 8.06 \text{ hp}$$

$$HP_f = \frac{(0.012)(160{,}000)(2.5)}{(550)(0.70)} = 12.50 \text{ hp}$$

Total required horsepower for trolley drive 20.56 hp

A 19-hp motor will serve the aluminum trolley, and a 33-hp motor is required for the steel trolley. These motors are also d-c mill and shovel motors.

HOIST DRIVE

The use of aluminum will have no influence on the power for the hoist since there is no dead weight influence. The horsepower required is:

$$HP = \frac{Lv}{550e}$$

where:

L = lifted load including impact factors
v = velocity of lift, ft per sec
e = efficiency

For the example shown the hoist power required for lifting at 30 fpm, or 0.50 ft per sec, including cable, block and hook weights amounting to 5000 lb, is:

$$HP = \frac{(105{,}000)(0.50)}{(550)(0.70)} = 136.0$$

A 135-hp, d-c motor can be selected for this service.

The motor requirements for the 50-ton aluminum and steel cranes are summarized as part of Table X. Before leaving the field of power equipment, some discussion of gearing, conductor and overall electrical economics is in order.

Since the motor size requirements dropped somewhat with the aluminum crane, it is also possible to reduce the size of gear reducers, shafts, conductors, contactors, and control equipment for the transmission of power to the bridge and trolley. This will result in a substantial reduction of weight for the drive systems of an aluminum crane which might be considered an added bonus over the horsepower savings. The designer may select aluminum as the structural material for his gear cases and safety caging. Figure 11 illustrates the case and gear train for the girder drive system on the 50-ton example crane. The use of aluminum in this application is encouraged, particularly where aluminum has been selected for the more massive girder and trolley applications. The weights of aluminum and steel castings are summarized in Table VI. Not only is weight saved but total casting costs are very low due to the high machining rates possible with aluminum.

Aluminum collector rails and conductor have been used to good advantage on aluminum cranes. The several means of development of conductor for collector rails, such as rod, figure "8" bar, angle or special "Y" shapes, have all been used successfully in aluminum. The cost of the aluminum conductor is substantially below equivalent capacity copper collectors at a substantial reduction in weight. Experience has shown that the aluminum collector rails will encounter no problems from surface oxide formation on the aluminum. By use of a carbon shoe, a carbon-aluminum-aluminum oxide impregnation is developed on the surface that maintains high electrical conductivity. The rapid advances in use of aluminum conductor for machinery applications makes the aluminum crane a prime candidate for inclusion. In the larger size conductors, aluminum is substantially below copper in cost equal-

TABLE X
Crane Motor Sizes for 50-Ton Example Crane

Construction	Aluminum		Steel	
	Motors	Cost	Motors	Cost
Hoist	1 @ 135 hp	$21,600	1 @ 135 hp	$21,600
Trolley	1 @ 19 hp	6,000	1 @ 33 hp	8,200
Bridge	2 @ 45 hp = 90 hp	19,500	2 @ 65 hp = 130 hp	25,100
Total		$47,100		$54,900
Savings on aluminum crane		$7,800		

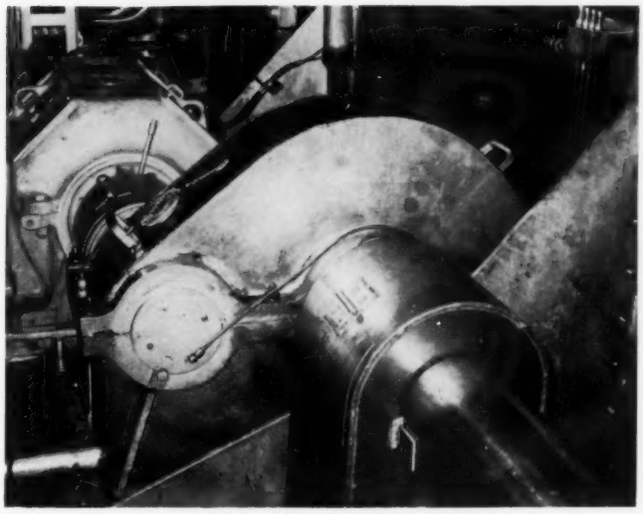
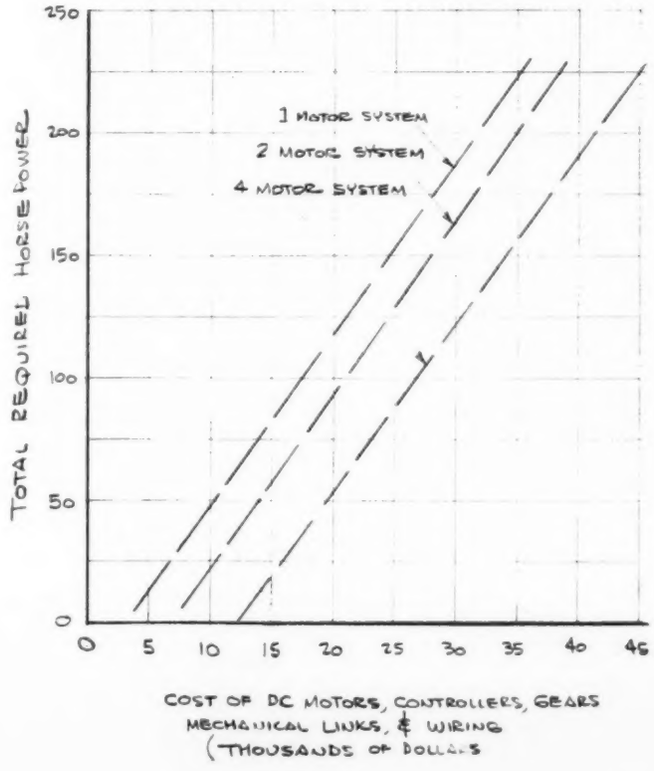


Figure 11 — Aluminum was selected for the case and gear train of the bridge drive system for the 50-ton example crane.

Figure 12 — From this curve the saving realized from reductions in required horsepower can be computed.



ling the cost of copper only in the small building wire sizes. Weight reduction can be carried concurrently with a cost reduction program. The problem of terminations of aluminum conductor are largely a thing of the past, and proper workmanship and installation of aluminum conductor will insure a trouble-free installation.

In an attempt to determine the cost savings possible by the use of lower horsepowers on the aluminum crane for the girder and the trolley, an estimating curve shown as Figure 12 has been prepared. This curve is based upon the cost of motors, gear reducers, controls and an arbitrary escalator of $50 per horsepower to include conductor costs and miscellaneous shafting for the mechanical train. The form of the curves should be a step function corresponding to motor sizing but has been leveled off for convenience. Using the example of the 50-ton crane drives, the gross costs of the electrical system will show a savings for the aluminum crane of $7800, which may be applied toward the premium for the aluminum structure, as shown in Table X.

FOUNDATIONS

Since the dead weight of the aluminum crane is substantially lower than that of the steel crane, economies in foundation design are possible through lighter wheel loads. This may develop either in design of foundations for new construction or in the requirements for modification of an existing runway to allow additional crane capacity without increase of foundation loads. The substitution of an aluminum crane for a steel crane will increase the payload capacity by at least one-third without a change in wheel load on the runways. This

Figure 13 — This curve illustrates the variation of the foundation cost as a function of foundation reaction loading.

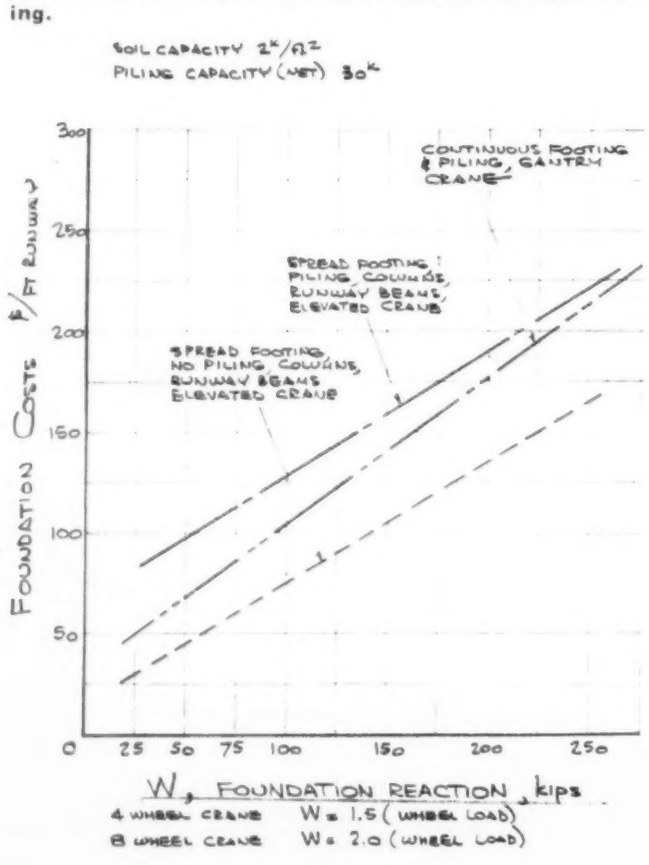


TABLE XI
Foundation Costs for 105-ft Span Aluminum and Steel Cranes of Table VI

Construction material	Aluminum	Steel
Number of wheels	8	8
Wheel loads, lb	52,200	71,500
Approximate foundation reaction, lb	104,400	143,000
Cost per ft of runway*	$128	$153
Cost per 500 ft of runway	$64,000	$76,500
Savings on aluminum crane	$12,500	

* Includes piling, spread footings, columns and runway beams.

can save considerable sums in foundation costs, new or modified.

In order to complete the analysis of the aluminum crane against that of the steel crane, Figure 13 has been prepared to represent simplified typical foundation costs for column-footing combinations for elevated runways and continuous footings for gantry type runways. The estimates are based upon concrete placed at $60 per yd on soil with a rated capacity of 2000 lb per sq ft and use of piling where required. Each pile is estimated to support an additional 15-ton load, reduced to allow for increase in dead weight of buildings and foundations to reach the maximum capacity of each pile. It is recognized that these foundation conditions are lower than are normally encountered in typical soils. Because selection of the light weight cranes is most logical for these marginal soil areas, these costs have been assumed for comparison. In order to show the magnitude of these foundation costs in the cost of the example 50-ton crane, a summary of gross foundation and runway structure costs for 500-ft runways on pile foundation footings

TABLE XII
Cost Summary, 105-Ft Span Aluminum and Steel Cranes

Construction material	Aluminum	Steel	Aluminum Premium
Crane weights, lb	170,500	311,500	
First cost of cranes			
Structure	$ 99,400	$ 70,600	$+28,800
Electrics	47,100	54,900	− 7,800
Remainder[a]	20,000	20,000	...
Fabricated cost	$166,500	$145,500	$+21,000
Freight[b]	2,650	4,840	− 2,190
Erection[c]	8,000	10,000	− 2,000
Adjusted first cost	$177,150	$160,340	$ 16,810
Ratio cost aluminum to steel	1.11		
Foundation costs, 500-ft runway[d]	$ 64,000	$ 76,500	$−12,500
Installed cost	$241,150	$236,840	$+ 4,310
Ratio cost aluminum to steel	1.02		
Maintenance (20 yr)			
Painting (indoor)	...	+4,870	− 4,870
Operation	...	+2,000	− 2,000
Gross adjusted cost for 20 yr	$241,150	$243,710	$− 2,560
Ratio cost aluminum to steel	0.99		

[a] Remainder includes items not structure or electrics, such as cab appointments, two 25-ton hoist drums and accessories, truck and rail mountings.
[b] Estimate based upon carload rail haul 500 miles at $1.55 cwt.
[c] Estimate placing in position, mechanical assembly and electrical terminations only.
[d] 500-ft runway.

for both the steel and aluminum cranes is tabulated in Table XI. These figures show that the structural material premium cost for the aluminum can be further reduced by $12,500 to take into account the savings in foundation costs.

MAINTENANCE

The use of an aluminum structure for craneway applications presents two opportunities for reduced maintenance: first, through the reduction of painting requirements; and second, through the increased life of runways, wheels and machinery due to the greatly reduced dynamic loads.

Maintenance painting of an exterior crane is generally a difficult problem in modern plant operation, requiring extensive rigging for painting those surfaces exposed to the weather but beyond the reach of the catwalk and girder levels. The frequency of painting of the outdoor crane will vary widely, depending upon the company's desire for appearance and the severity of the atmosphere. This may vary from 2-year intervals to 15-year intervals as an average for all surfaces. Certain components in the vicinity of the moving parts are painted with frequencies much shorter than that of the cumbersome structural components. For an indoor installation, painting becomes much less of a problem unless the atmosphere for some reason has a concentration of corrosive chemicals or high humidity condensation. For purposes of estimating maintenance costs of steel and aluminum cranes, an arbitrary assumption of complete painting at 5-year intervals for the outdoor steel crane and 10-year intervals for the protected crane is assumed. By way of contrast, it is estimated that the aluminum crane, by virtue of the small surface area of steel and the probable freedom of painting requirements of aluminum surfaces, would require an equivalent one-third frequency of the all-steel unit. Using a rule of thumb estimate of $0.015 per lb of structure for each steel painting cycle or $3660, the 20-year costs would produce:

	Steel crane	Aluminum crane	Savings of aluminum crane
Indoor	$ 7320	$2440	$4870
Outdoor	$14,640	$4880	$9760

Assigning a monetary value to structural and electrical maintenance is an even more difficult task than estimating future painting costs. It is assumed, for purposes of evaluation, that three complete renovations would be required for the steel crane and two for the aluminum crane over the same 20-yr period. This could provide an estimated credit for aluminum of $2000 over this period. Some slight gain in cost of electric power is also possible but will be very small unless

TABLE XIII
Aluminum Alloy 5083

ASTM designation: GM41A
Federal specifications: plate ASTM B209; Mil-A-17358A; extrusions Mil-A-19005
Availability: plate as H113, Extrusions as H112
Typical applications: very heavy weldments, ships, tankage, cranes, trailers

Physical Properties

Density, lb per in.^{3}	0.096
Modulus of elasticity, psi	10.3×10^6
Modulus of shear, psi	3.87×10^6
Coefficient of thermal expansion, in. per in. per F	13.0×10^{-6}
Thermal conductivity, Btu per hr per ft^2	960

Mechanical Properties (guaranteed)

Temper	O	H112	H113
Ultimate strength, psi	40,000	40,000	44,000
Yield strength, psi	18,000	24,000	31,000
Elongation in 2 in., per cent	16	12	12

Mechanical Properties (typical)

Ultimate shear, psi	25,000	27,000	30,000
Endurance limit, 5×10^8 cycles	15,000	..	23,000

Mechanical Properties of Welds (typical)

Welding wire	5356	5183	5183
Ultimate strength, psi	38,000	40,000	42,000
Yield strength	17,000	19,000	21,000
Elongation in 2 in., per cent	15	15	15
Formability, 90-degree bend, times	1½	2	3

Corrosion resistance: excellent, particularly for marine applications

Chemical Composition, nominal, per cent

Cu	Zn	Mn	Cr	Ti	Mg	Si
0	0	0.75	0	0	4.45	0

TABLE XIV
Aluminum Alloy 5086

ASTM designation: GM 40A
Federal specifications: Sheet and plate ASTM B209; Mil-A-19070
Availability: sheet as O, H32, H34, H36; plate as O, H112
Typical applications: heavy weldments, storage tanks, highway tank, dump, flat bed trailers

Physical Properties

Density, lb per in.	0.096
Modulus of elasticity, psi	10.3×10^6
Modulus of shear, psi	3.87×10^6
Coefficient of thermal expansion in. per in. per F	13×10^{-6}
Thermal conductivity, Btu per hr per ft^2	870

Mechanical Properties (guaranteed)

Temper	O	H32	H34	H112
Ultimate strength, psi	35,000	40,000	44,000	36,000
Yield strength, psi	14,000	28,000	34,000	18,000
Elongation in 2 in., per cent	18	8	6	8

Mechanical Properties (typical)

Ultimate shear, psi	23,000	25,000	27,000	26,000
Endurance limit, 10^6 cycles	..	..	19,000	..
Endurance limit, 5×10^8, cycles	..	..	15,000	22
Brinell hardness	60	75	80	65

Mechanical Properties of Welds (typical)

Welding wire	5356	5356	5356	5356
Ultimate strength, psi	35,000	37,000	38,000	36,000
Yield strength	14,000	18,000	19,000	18,000
Elongation in 2 in., per cent	15	12	10	12
Formability, 90-degree bend, times	1	1½	2	1½

Remarks: (a) 5183 equal to 5356

Corrosion resistance—excellent, common marine alloy

Chemical composition, nominal, per cent

Cu	Zn	Mn	Cr	Ti	Mg	Si
0	0	0.45	0.10	0	4.0	0

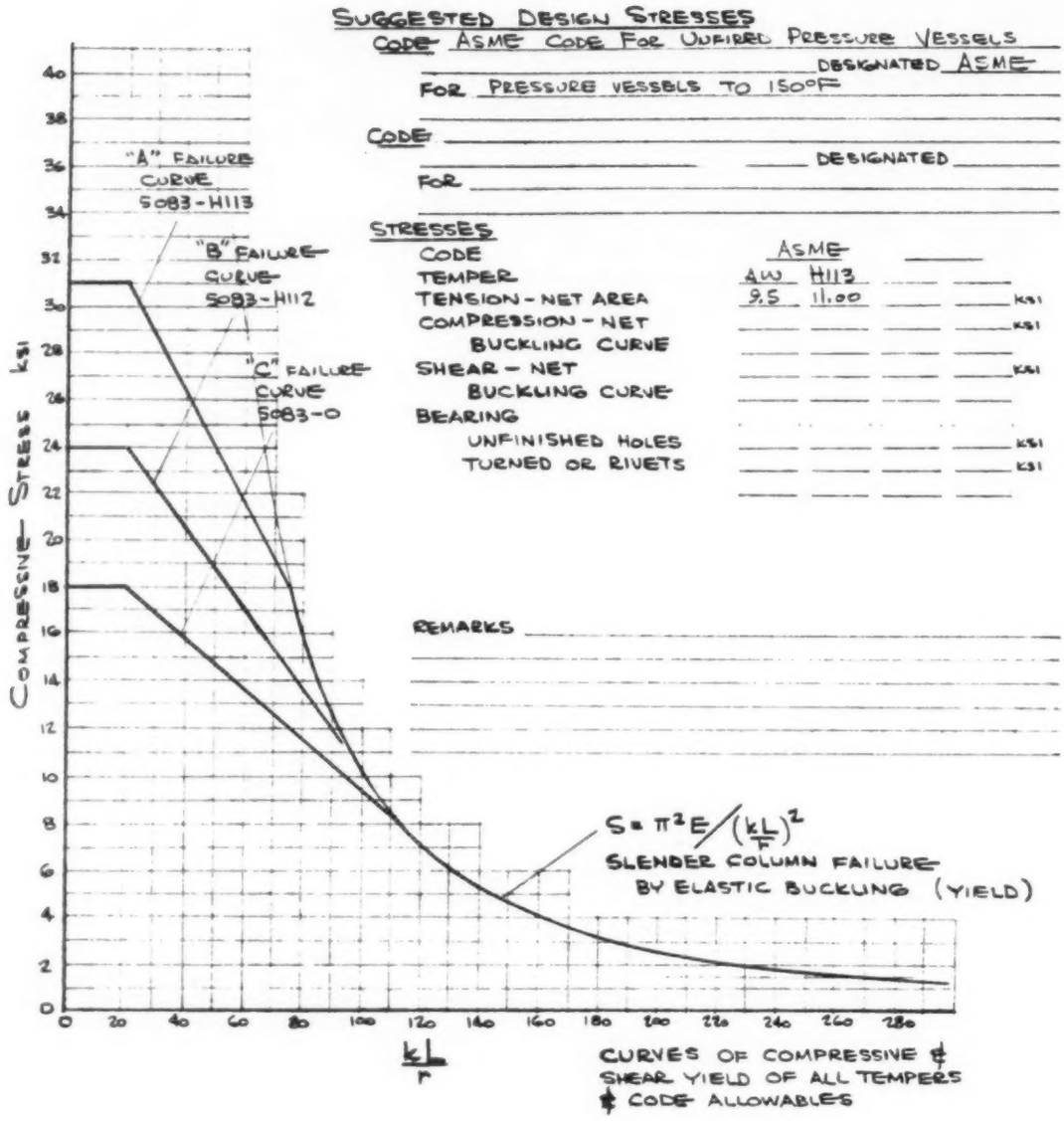


Figure 14 — These curves show suggested compressive design stresses for aluminum alloy 5083 as a function of $\frac{KL}{r}$ where K is the column end fixity factor, L is the effective length of the column under compression, and r is the radius of gyration of the column section.

the crane operates continuously. This is carried over into the cumulative economic section shown in Table XII.

SAMPLE STRUCTURAL SPECIFICATIONS

Although the recommended aluminum alloys for structural application on cranes are reviewed in the Appendix, it is felt that sample structural specifications for an aluminum crane might be useful to the designer. These specifications are included in the Appendix and are restricted in intent to the structural components only. For the remainder of the equipment facilities and structures in connection with the aluminum crane, the designer is referred to either the AISE Standard No. 6 or the Electric Overhead Crane Institute Specification 49.

ECONOMIC SUMMARY

At the beginning of this discussion, it was pointed out that there are two reasons for considering aluminum for traveling overhead cranes: weight and cost. The weight aspect of crane development is necessarily a design condition with the lifting load and dimensions established by the customer and the weight of the crane following through design calculations.

On a component piece basis, aluminum and steel crane economics have been reviewed for structures, equipment, electrics, foundations, and maintenance painting. Other items influence the gross total cost of the installation in a smaller way, such as freight and erection. These estimated figures have now been assembled into Table XII to provide a rapid comparison of what can be expected by designing the 50-ton, 105-ft 0 in. span crane with aluminum. The reader should note that the first cost of the aluminum crane can be estimated at $21,000 or 13.5 per cent more than the steel crane. This premium progressively drops when freight and erection are added and foundation costs for an arbitrary 500-ft runway are included to produce an installed crane for $241,150 in aluminum with a premium of only $4310. Finally, when the extrapolated 20-year maintenance costs are included, a saving results in use of an aluminum crane of $2560.

For those firms that are particularly interested in the maintenance aspects of crane applications, such as utility companies and shipyards, with their corrosive atmospheres and prestige industrial facilities, the aluminum crane may well prove to be substantially more attractive than the steel crane.

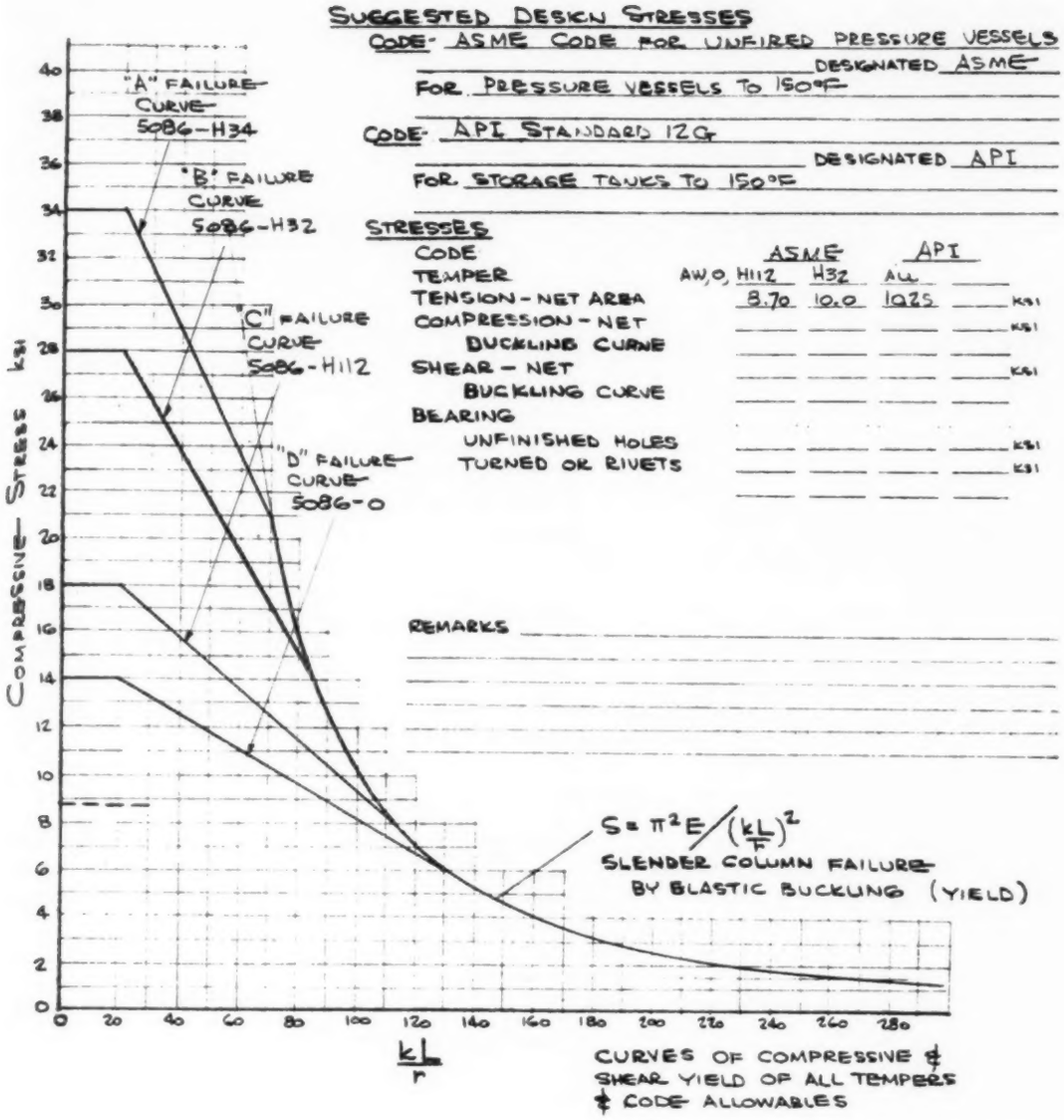


Figure 15 — These curves show suggested compressive design stresses for aluminum alloy 5086 as a function of $\frac{KL}{r}$ where K is the column end fixity factor, L is the effective length of the column under compression, and r is the radius of gyration of the column section.

APPENDIX

Simple Structural Specifications: Aluminum Electric Overhead Traveling Cranes

0.01 *Scope A*

A. This specification shall serve as an addendum to the applicable specification outlined in 1 or 2: (1) "Association of Iron & Steel Engineers Specifications for Electric Overhead Traveling Cranes for Steel Mill Service," AISE Standard No. 6, latest revision; (2) "Specifications & General Information for Standard Industrial Service Electric Overhead Traveling Cranes," Specification 49, latest revision.

The work covered under this section shall consist of furnishing all labor, materials, services and tools to construct aluminum components for the specified cranes.

0.02 *Aluminum Applications*

A. The following components of the structure shall be of aluminum construction:
   a. Girders
   b. Trolley frames
   c. End ties
   d. End trucks
   e. Walkways, stairs and ladders
   f. Cab
   g. Bumpers
   h. Gear boxes
   i. Resistor packs
   j. Machinery guards

0.03 *Materials*

A. Materials or construction for the primary structural components, i.e., girders, trolleys, end ties, shall be aluminum alloys 5083 and 5086 in accordance with the following availability schedule:
   1. Plate 0.501 in. and heavier, to 84-in. maximum, shall be 5083–H113.
   2. Plate 0.401 in. to 0.500 in. by 75 to 96 in. maximum, shall be 5083-H113.
   3. Plate 0.401 in. to 0.500 in. to 75 in. wide and all sheet and plate 0.400 in. and thinner shall be 5086–H33.
   4. Primary load structural shapes shall be 5083-H112.
   5. Secondary structural shapes, rod and pipe shall be 6061-T6.

B. Materials of construction for secondary structural

components, i.e., walkways, cabs, ladders, shall be aluminum alloys 5083, 5086 or 6061-T6 optionally in accordance with the following availability schedule above. Alloy 6061-T6 is available in all plate sizes and structural shapes.

C. Welding filler wire shall be 5356 or 5183 with a class C finish.

D. Aluminum castings, where desired, shall be alloy 356-T6.

0.04 *Factors of Safety and Design Stresses*

A. Design shall be in accordance with applicable desired specification listed in Section 0.01 "*Scope*". In the event of conflict, the structure shall be designed for a minimum factor or safety of 5.0 based on ultimate strength.

B. Welding of alloy 6061-T6 in areas of higher stress should be minimized.

C. Stresses influencing compression buckling should be minimized as the lower modulus of elasticity prevents large stresses.

Deflection

A. The maximum vertical deflection of the girder, produced by the rated load and weight of the trolley only, shall not exceed 0.0015 in. per in. of span. Impact should not be considered in determining deflection.

or

B. The maximum vertical deflection of the girder, produced by the dead load of the girder and trolley and the rated load, shall not exceed 0.00125 in. per in. of span. Impact shall not be considered in determining deflection.

0.06 *Fabrication*

A. Fabrication of structural components shall be in conformance with good industrial practices, utilizing welded construction whenever practical.

B. Welding shall be by inert gas shielded electrode using 5356 or 5183 filler wire and argon and/or helium gas. The use of gas welding or coated electrode welding will not be accepted. Weld preparation shall include wire brushing all surfaces and removing grease, oil and wax. Welds shall be back-chipped as required to make sound welds. Intermittent welds shall be spaced not less than 10 times the nominal minimum plate thickness and shall be of length at least 5 times the minimum plate thickness or $2\frac{1}{2}$ in., whichever is larger.

C. Material shall be fabricated from plate by sawing, milling, or heli-arc cutting at the option of the fabricator. No conventional flame cutting shall be used. Structures shall be so constructed to prevent accumulation of water or oil within crevices or pockets. Steel or copper and aluminum joints shall be constructed to prevent the entrance and accumulation of moisture on the interfaces.

D. Bolts and nuts shall be steel alloys with cadmium or zinc plated surfaces. Reamed holes shall be utilized whenever possible. Double thickness, full bearing washers shall be used. Bolting shall be used only where it is necessary to have removable components and shall not be used to assemble the primary structures.

0.07 *Finishing of Aluminum*

A. Aluminum plate and structural shapes shall be inspected for and stored to prevent stains due to water, oil or weathering prior to fabrication and delivery.

B. Aluminum surfaces shall not be painted but shall be free of stains caused by storage or fabrication.

C. Steel or copper alloy surfaces in contact with aluminum shall receive a prime coat or zinc chromate followed by two coats of paint approved by the purchaser. ▲

AISE Merit Scholarship Available Next Year

The AISE, which for some years has sponsored an annual four-year National Merit Scholarship, has changed its eligibility rules to give preference to children of AISE members if they are otherwise eligible to meet the requirements of the scholarship. The scholarship is awarded to a student who intends to study mechanical, electrical, metallurgical, civil, or chemical engineering.

Persons interested in applying for the National Merit Scholarships should apply at once at the principal's office in his high school and register for the qualifying examination. Examinations will be given in all schools which register students for merit scholarships. Testing dates are Tuesday, April 28, and Saturday, May 2, 1959 at 9:00 A.M. Finalists in the scholarship competition will be named after a second examination, now scheduled for December 2, 1959.

Students who are eligible are second semester juniors and first semester seniors in public, parochial or private schools located in any of the 49 states. A charge of $1 per student is made for the examination. The examination enters the student in all National Merit Scholarship programs and certain other scholarship competition.

In the 1959–60 academic year the National Merit Scholarship Corp. will provide more than $5,000,000 worth of four-year scholarships. The amount of the scholarships are determined by financial need and they are renewable annually without further competitive examination.

Last year's AISE scholarship was won by Henry Halsey Knapp III of Altadena, Calif. Henry Knapp was a student of the John Muir High School and is a freshman majoring in electrical engineering at the Massachusetts Institute of Technology. Other current holders of AISE Merit Scholarships are Ralph D. Gray, Jr. of Killbuck, Ohio, who is in his third year at Case Institute of Technology and Robert L. Porter, of Wauchula, Florida, who is in his second year of electrical engineering at Georgia Institute of Technology.

Electrical Equipment For A High-Speed Annealing Line

New line is designed to handle 45-in. wide, 85-in. diam, 60,000-lb coils at speeds up to 2000 fpm.

by J. E. Butler,
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Weirton Steel Co.,
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THE development and increased capacity of continuous annealing lines are proceeding at a spectacular rate similar to that previously achieved in the cold rolling and electrolytic tinning fields. In both instances the need was present and the general method of solution known for many years, but there were also many details to be worked out and much capital investment required.

A continuous annealing pilot line was installed in a mid-west steel plant as early as 1932. The solution of the problems faced by that and other similar pioneer lines has made possible the realization of the 2000-fpm line.

The Weirton line has a nominal rating of 60 tons per hr when processing low carbon steel 0.010 in.-thick, 30 in. wide at 2000 fpm and 1350 F. The nominal furnace temperature for this schedule is 1600 to 1650 F. Higher tonnage rates are available with increased strip width, increased furnace temperature and higher speeds. The line is designed to process coils up to 45 in. wide having an inside diameter of 16½ in., maximum outside diameter of 85 in. and a maximum weight of 60,000 lb. The strip thickness range is 0.0075 to 0.015 in., and 0.0045-in. strip has been successfully annealed. Figure 1 is a sketch of the pass line.

The line was designed to provide operational flexibility. This involved both the mechanical and electrical components and has pioneered into higher process speeds and thinner gages of strip.

The line has three sections, the middle section being the annealing section and the keynoter for line speed. The nominal top speed for this section is 2000 fpm. The speeds of all sections are adjusted by generator voltage control with the motor field control used only for coil build-up, loop control, and vernier load adjustment of helper drives.

There are looping towers before and after the annealing section to provide storage so that it is not necessary to stop the line for the welding operation at the entry end or reel transfer at the delivery end. Each looping tower has a storage capacity of 700 ft and consists of 14 passes with a working travel of 50 ft. This corresponds to 21 sec downtime for a 2000-fpm furnace section speed and necessitates, when operating at top speeds, slowing down the annealing section to 500 fpm during the coil welding. When these operations have been completed, the entry and delivery sections are operated above the 2000-fpm nominal speed by generator voltage control to rapidly refill the entry end strip looping tower and remove the excess strip from the delivery end tower. Because coil build-up on the winding reels is small during these periods, provision is made to prevent reel motor overspeed.

The entry section of the line is powered by a 250-kw, 275-v d-c generator under the combination control of a motor-operated generator field rheostat and photoelectric control. The generator field rheostat provides uniform acceleration and deceleration at any desired rate, and the photoelectric control maintains the speed relationship between sections to insure the looping tower being full. The line speed will not exceed 2000 fpm during the normal operation of this section with the looping tower full, but after a slowdown period the generator voltage may be raised to 275 v with a corresponding increase in speed to 2400 fpm.

Strip is fed into the line from either of two mandrel type uncoiling reels powered by 150-kw, 200/1200-rpm,

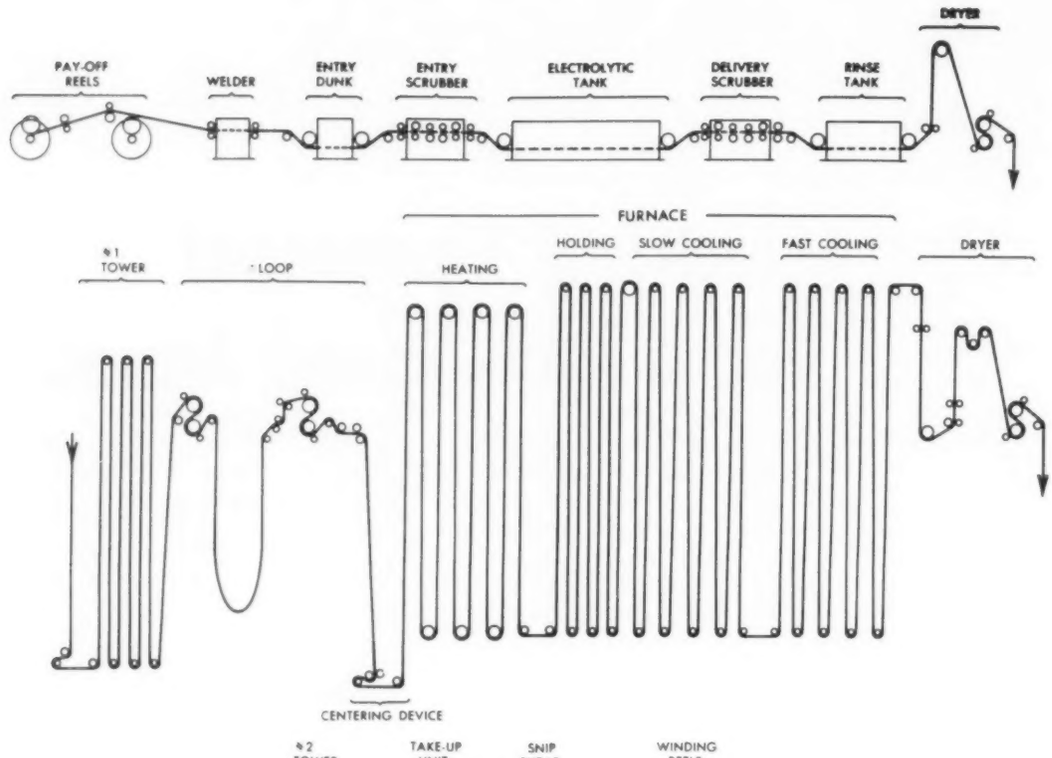


Figure 1 — Pass-line diagram of the high-speed continuous annealing line.

230-v d-c drag generators which operate as generators as soon as tension is established. Eash pay-off or uncoiling reel drive drag generator is in series with a booster generator which supplies power for forward and reverse logging of the reel not in service. These booster generators also provide stall tension capacity and IR compensation for the reel feeding strip into the line. The fields of these reel motors are controlled to provide current limit, inertia compensated tension control. Between the pay-off reels and the No. 1 bridle, which may be considered the keynoter for the entry section of the line, are 18 helper roll drives. These motors are compound wound with characteristics to insure load sharing stability at all speeds.

As previously mentioned, the No. 1 bridle is the keynoter for the entry end section. The top roll of this bridle is driven by a 50-hp motor and the bottom roll by a 150-hp motor. Special cross-connected series fields insure that load division between these motors is proportional to their ratings. A deviation from this ratio may be obtained by adjustment of their shunt field vernier rheostats. This system provides positive load division, regardless of the rapidity of load changes, and unfailing reliability.

The middle or annealing section of the line is run at constant speed except for slowdowns when a weld is made. The strip enters this section from the No. 2 bridle which has a top roll powered by a 50-hp motor and bottom roll driven by a 25-hp motor. These motors have the same provision for load division as the No. 1 bridle roll drive. There is a single loop between No. 2 and 3 bridle rolls. The No. 3 bridle rolls are powered by two 19-kw drag generators.

The thirteen 5-hp and forty 3-hp annealing furnace roll drives convey the strip through the furnace and precede the No. 4 bridle rolls. A 38-kw drag generator is connected to the top roll of the No. 4 bridle, and the bottom roll drives a 19-kw drag generator.

The No. 2 bridle booster field is regulated by a photothyratron modulated loop control to maintain the position of the free hanging loop between the No. 2 and 3 bridle rolls. For a short period the line was operated as a tight line without this loop and with the No. 3 bridle rolls idle. The advantage of insuring the strip entering the furnace in the center of the pass line warranted reinstalling this loop. Reinstalling this loop also eliminated transfer of sudden shocks from the entry end of the furnace section.

The No. 3 bridle roll motor speed was initially controlled by the position of the mechanical tension device through an electronic position control. The tension device consists of two fixed and one movable roll, the latter biased by an air cylinder. The air pressure is adjusted by a pressure control, and the strip tension entering the furnace is controlled very accurately over a range of 50 to 1000 lb. It has been found

in practice that the wide range and the high degree of tension accuracy provided by the tensiometer was not required for present operators. The No. 3 bridle is now under current control, and the No. 1 tensiometer is bypassed.

The 5-hp and 3-hp furnace rolls have trimmer rheostats and ammeters for their control as described for the similar motors in the entry section. These motors serve as the keynoter for the annealing section. An air-operated tensiometer, similar to that previously described for the entering side of the furnace, controls the tension between the furnace and the No. 4 bridle. All motors in the middle section are powered by a 250-kw 275-v generator with separately excited field controlled by a motor-operated generator field rheostat with control switch on the master desk. The position of this rheostat determines the line speed.

The strip enters the No. 2 looping tower from the No. 4 bridle and is pulled out of the tower by the No. 6 bridle rolls. The No. 6 bridle rolls and the two winding reels are driven by the 250-kw, 275-v generator for the delivery end section of the line. The No. 5 bridle is driven by 50-hp and 25-hp motors. This bridle is not being used since the line is now operating tight between the No. 2 looping tower and the winding reels. The reel shifting regulators insure coils with straight edges so that it was possible to eliminate the free standing loop and the No. 5 bridle. The No. 6 bridle has a 38-kw drag generator connected to the top rolls and a 56-kw drag generator coupled to the bottom rolls.

The speed and acceleration of the delivery end section is matched to that of the annealing section through a motor-operated rheostat and a photoelectric control to insure the looping tower being empty.

Each winding reel is driven by a 200-hp, 200/1200-rpm motor and is controlled by a rotating type current regulator for tension control similar to the pay-off reels.

Provision is made with a special double-cut shear and pusher pinch roll to cut and transfer from the full to empty delivery reels at strip speeds up to 500-fpm. The pusher pinch rolls are driven by a 75-hp motor and are synchronized with the strip speed. They engage the strip before the cut and are in contact until the strip is wrapped on an empty reel.

Many of the drive techniques have been previously developed for other process lines. This installation is closely associated with Weirton tinning line practices.

The furnace has a radiant tube, gas-fired heating section with 12 passes. There are nine passes in a holding zone which is electrically heated, 11 passes in a slow cool zone, and 15 passes in a fast cool zone. Following the furnace is a water quench and air dryer. A very complete description of this furnace is given in a paper "Furnaces," by C. E. Peck in the 1957 Procedings AISE.

CONTINUOUS ANNEAL BUILDING

The annealing building, whose layout is shown in Figure 2, contains three 2000-fpm, 45-in wide, continuous annealing lines each rated 60 tons per hr. The building is 121 ft wide x 560 ft long center-to-center of columns. The peak of the roof is approximately 120 ft above the floor (Figure 3).

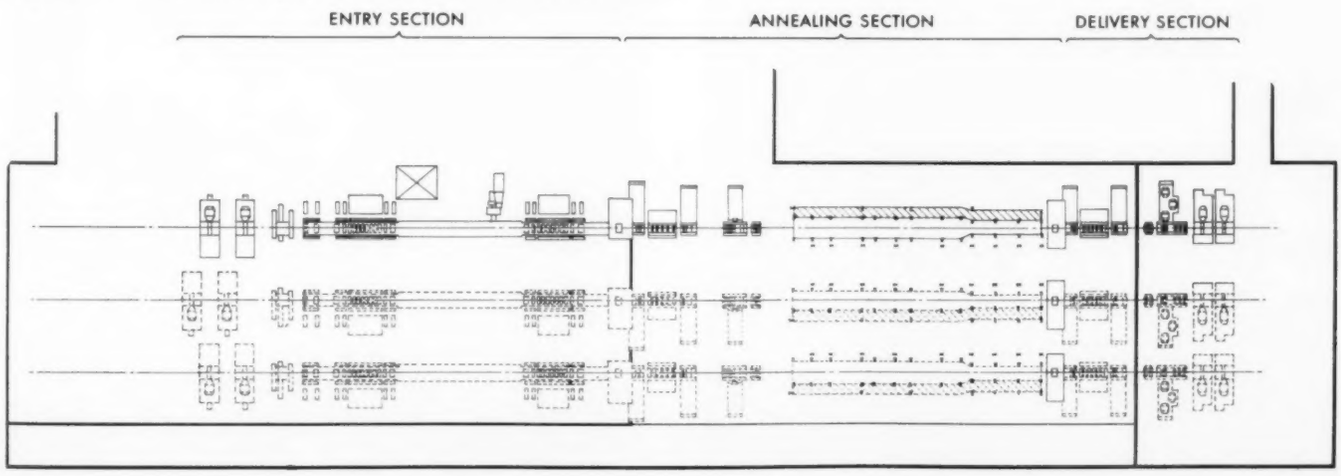
The fourth or top floor is at the same elevation as the original Tin Mill Dept. and is used as the operating floor for the equipment. With this method of construction the required looping towers, before and after the annealing furnace, were placed downward through the building rather than elevated as in designs where the operating floor is at grade. The fourth floor is designed for 3500 lb per sq ft to accommodate coil storage at both ends of the lines.

The third floor is used as a service floor and contains the substations and other service equipment required in the operation. This floor is designed for 500 lb per sq ft and is a totally waterproof floor with an asphalt-covered membrane as part of its waterproofing system.

The second floor is designed for tin plate storage and 3000 lb per sq ft, and the first or basement floor, also used for tin plate storage, is designed for 3000 lb per sq ft.

The foundation was designed as a retaining unit to withstand the force required to hold up the balance of the tin mill, which was originally installed at the top of the hill. There are seven concrete buttresses, each 40 ft deep x 90 ft long and approximately 13 ft wide, designed with 2 ft of the concrete penetrating into rock and securely doweled into the rock. On the top of these buttresses a 4-ft thick solid concrete pad was poured to serve as the first floor. The foundation was designed for 10,000-lb per sq ft live load.

Figure 2 — The annealing building accommodates three lines.



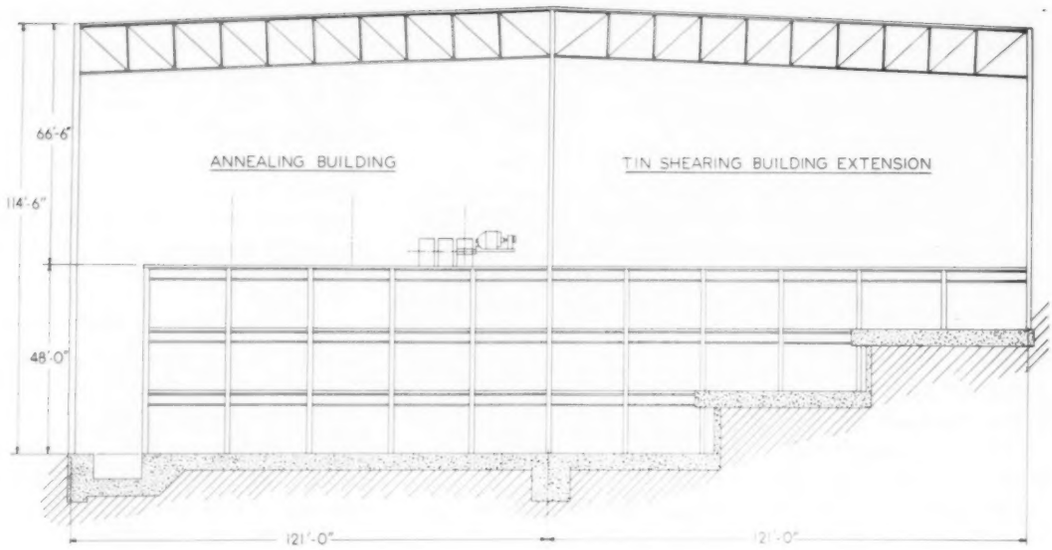


Figure 3 — This cross-section elevation of the annealing building shows the top floor of the annealing building to be at the same elevation as the original tin mill dept. The top floor is the operating floor for the equipment, and the furnace and looping towers extend below it.

There were approximately 45,000 yd of concrete, 10,000 ton of reinforcing steel, 300,000 lineal ft of bearing tile and 20,000 tons of structural steel. The largest columns are 65 tons each.

The building is serviced on all floors by a 30-ton elevator, installed primarily for the moving of tin plate from the operating floors to the warehouse areas, and by a passenger elevator.

The questions which have been asked most in discussions of this installation are:

1. Is the product satisfactory?
2. What speed is the line operating?
3. What are the tonnages?
4. What ratings would be recommended for a new installation?
5. What are the problems, tracking, buckling, slippage, welds, etc?
6. What do the results of this installation indicate for the future?

To the first of these questions the answer is definitely yes. The product is satisfactory, and this includes the steel annealed during the slowdown period when coils are being welded.

The principal metallurgical problem existing with continuous annealed plate is temper. Under normal operating conditions the temper is normal (about 60 Rockwell) off the annealing line. This varies only slightly, becoming softer while the strip is traveling at weld speeds but not soft enough to affect the temper of the end product. It has been found that after temper rolling, the weld-speed material shows physical properties and microstructures so near the normal-speed steel that they are practically undistinguishable. Under annealing is very rare, and excessively hard steel in practically all cases is found to be due to its chemistry. No difficulty traceable to the cooling cycle has been found to date.

The production of the line to date may be summarized as follows:

Aug. 1, 1957—test run
From Aug. 1, 1957 to Aug. 27, 1957—Tune-up, train crew
Starting Aug. 27, 1957—two-turn operation
Starting Sept. 7, 1957—three-turn operation
Production increased to 13,100 tons in March, 1958
Maximum in one hr—50 tons
Maximum in one turn—356 tons
Maximum in 24 hr—904 tons

Figure 4 — This is the complete annealing line as viewed from the top floor.

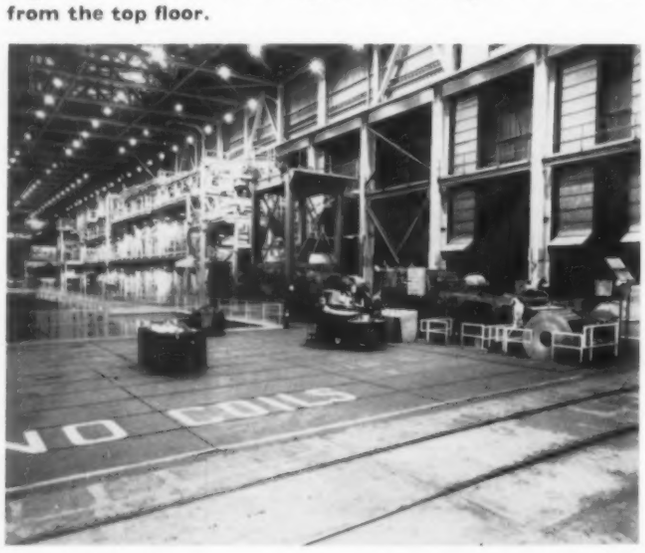


Figure 5 — The front or entry end has two pay-off reels in order to keep coil charging from interrupting the continuity of the annealing process.

Average turn in March, 1958—219 tons (60 per cent of product was 75-lb plate)
Minimum gage run—0.0045 in.
Maximum gage run—0.0130 in.

Tables I and II may assist in future selection of ratings.

Tracking and buckling are related to the shape of the strip, alignment of rolls, strip tensions, temperatures and speed. They are no longer a serious problem in the line. Slippage was never a problem.

TABLE I
Motor Current Readings When Annealing 0.0117 x 28 13/16-in. Strip at 1500 Rpm

Motor	Current, amp	Per cent of full load current
Pay-off reels	300	46
No. 1 Bridle		
Top	100	56
Bottom	280	52
No. 2 Bridle		
Top	80	45
Bottom	40	44
No. 3 Bridle		
Top	55	66
Bottom	55	66
Annealing furnace, 12 motors	3	16
Hold and slow cool, 17 motors	7½ per motor	70
Fast cool, 22 motors	7½ per motor	70
No. 4 Bridle		
Top	40	24
Bottom	20	24
No. 6 Bridle		
Top	120	73
Bottom	140	57
Winding reel	452	62
Entry section generator	260	29
Furnace section generator	410	45
Delivery section generator	200	22

Accelerating time for the furnace section from 250 to 2000 fpm is 75 sec.

TABLE II
Annealing Line Temperatures for 0.0117 x 28 13/16-in. Strip at 1500 Fpm

Section	Furnace Temperature, F	Strip Temperature, F
Heating zone	1350	1130
Hold zone	1250	1250
Slow cool zone	1050	800

Figure 6 — The furnace portion of the line is approximately four stories high.

The mash welds are strong and permit temper passing at operating speeds. A weld requires about 45 sec.

The line has been in operation for approximately eight months. During this period the speed has gradually been increased so that the present normal operating

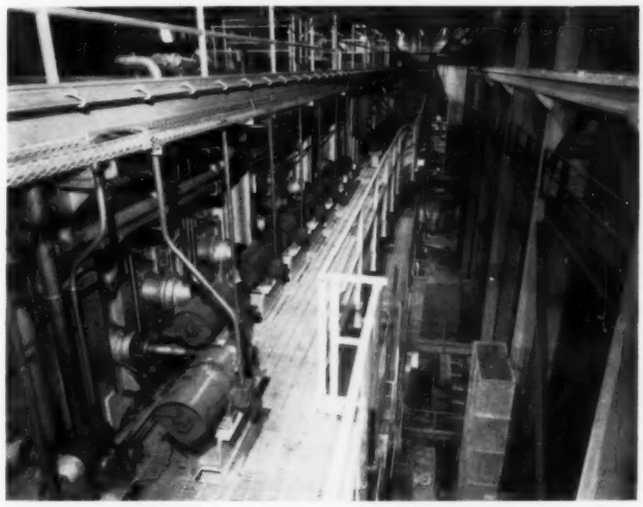
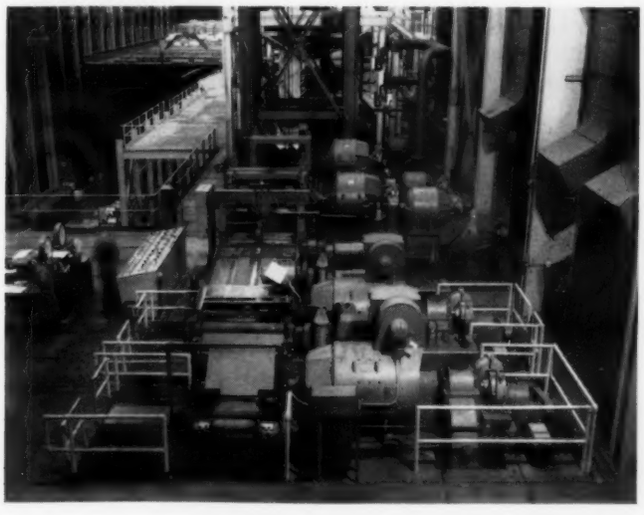


Figure 7 — The furnace rolls are motor-driven.

Figure 8 — The No. 2 looping tower is shown here.

Figure 9 — The delivery or exit end of the line has two winding or tension reels in order to keep strip shearing and coil removing from interrupting the continuity of the annealing process.



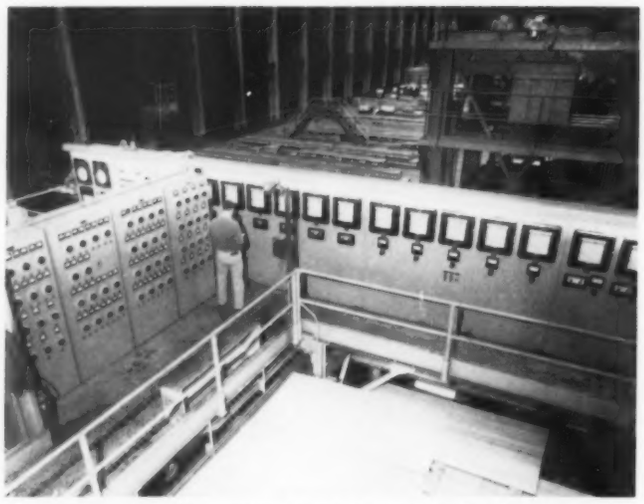


Figure 10 — These control panels are for the furnace.

range is 1500 to 1750 fpm. It should be noted that this is not the expected ceiling. On certain schedules very satisfactory operation has been obtained at 2000 fpm; it is the writers' opinion that this line speed will be exceeded.

Discussion

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John Barinaga: Since the Weirton Steel continuous annealing line is designed for 2000 fpm, the industry has watched it with a great deal of interest. The scheme of control varies somewhat from the systems being used on other high-speed annealing lines. The scheme using motor-operated rheostats for controlling the fields of the entry and delivery section generators does not offer some of the advantages that can be attained with the use of speed or voltage regulators. This is especially true since the development of the rate-of-change regulator of the type we furnished on our most recent annealing line. Among the added features of rate-of-change regulation are:

1. Linear rate of change of speed independent of the total change in speed.

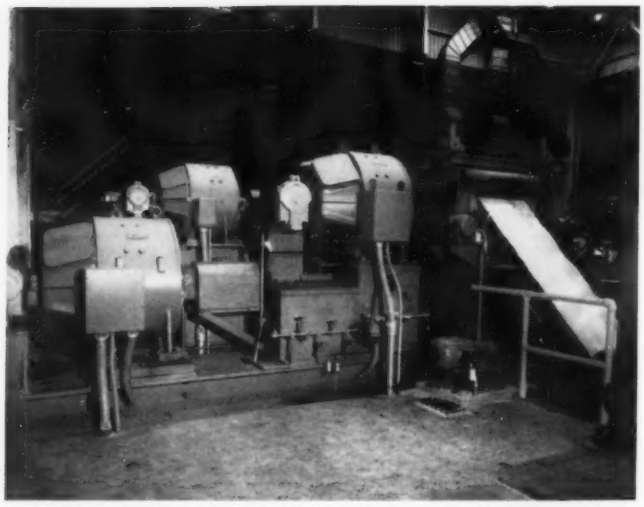


Figure 11 — This is a closeup of the No. 6 bridle and pinch roll.

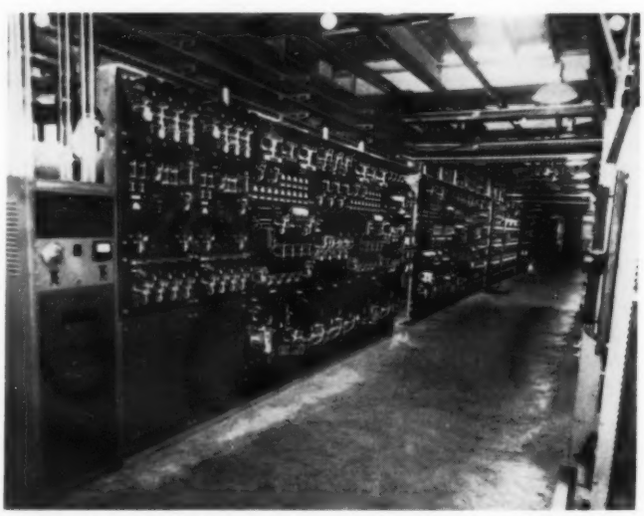


Figure 12 — One of the furnace control panels in the motor room.

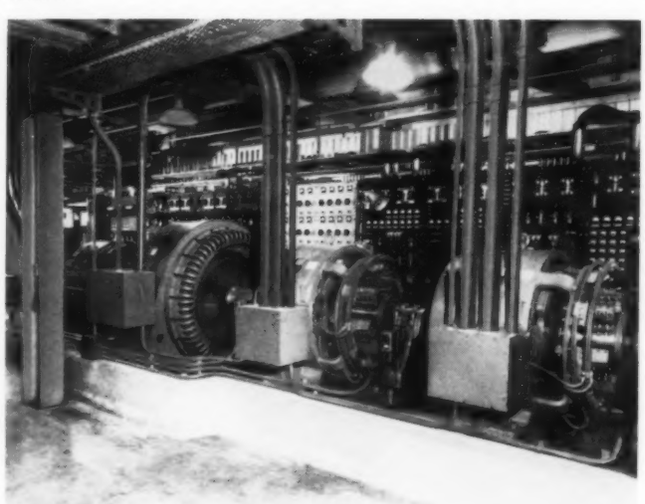


Figure 13 — Shown here is a motor-generator set in the motor room.

2. Elimination of the inherent maintenance required on motor-operated rheostats.
3. Elimination of the necessity for dynamic braking to final stop.
4. Simplification of accurate inertia compensation.

The added cost of these refinements are a small

percentage of the installed cost of such a line and have been economically justified by many users of high-speed processing lines.

Other differences are the use of the furnace section helper drives as the pacer for the furnace section and the setting of tension with the bridles on *both* ends of the furnace. On common-bus sections usual practice has been to use the largest drive as the pacer and match the other drives by IR and inertia compensation. Ideally the function of the helper drives is to overcome the roll friction and roll inertia during speed changes to prevent tension build-up in the strip. It appears that in the system described by the author any difference in tension set at the entry and delivery end would have to be absorbed or contributed by the roll drives.

If the data are available, it would also be very interesting to know the actual variation in hardness in points Rockwell between the strip annealed at say 1500 fpm and that annealed at the reduced speed during coil welding. If we consider operation at the nominal speed of 2000 fpm, during slowdown to 500 fpm the strip will be in the furnace heating section four times as long as it is at 2000 fpm. Since the heating section of the furnace consists of a large mass of bricks and steel tubes, all up to temperature when slowdown begins, there will be some time lag in the reduction of furnace temperature. The higher the thermal efficiency of the furnace operation, the greater this time lag will be. Hence, it does not seem unreasonable that some of the strip would be heated as much as 100 to 150 F above the desired temperature during a slowdown of this extent.

Based on the investigations of A. F. Mohri of the Steel Co. of Canada as reported in his paper to the American Iron and Steel Institute in May, 1956, an increase of maximum strip temperature of 50 F decreases hardness of the steel by approximately one point Rockwell for strip temperatures above 1170 F up to a critical temperature which he found to be around 1333 F. His findings also indicated that temperatures above the lower critical resulted in an abrupt increase in hardness of as much as 2 points Rockwell for a 50 F increase in temperature above the critical. Therefore an increase in strip temperature of 100 F, from 1200 to 1300 F, could decrease hardness by 2 points Rockwell, or an increase of only 50 F above the critical temperature could increase hardness as much as 2 points. These values, of course, may vary somewhat with steel composition. If the steel producer were attempting to hold annealed hardness within a band of three points Rockwell, it appears that the slowdown operation, with the wide differential between normal speed and welding speed, might result in at least some of the strip having hardness outside the desired band. This hardness variation will be less as the amount of furnace slowdown is decreased. Nevertheless slowdown means reduction of line production. Hence it would be interesting to compare actual results on this line with the earlier test data.

Willard G. Cook: It is not within the scope of this paper to discuss in detail the control system or the many features incorporated in it to provide the utmost in performance and flexibility. These points are stressed since it was recognized that pioneering into the higher annealing speeds would unveil new and unforeseen problems which might necessitate electrical and mechanical modifications.

A high-speed annealing line has many special requirements. Wherever possible the direct, straightforward approach to the basic operation was chosen. As an example, where very accurate tensions over wide ranges were required, tensiometers were designed for the specific conditions. The idea of the furnace roll motors being the keynoter was new. The control was designed for the new or conventional operation. Both were tried and the new system selected. The line is backed up by emergency dynamic braking which is only operative in case of a device failure, overvoltage, overspeed or field failure. This line provides a constant and adjustable rate of acceleration for the entry and delivery sections regardless of the operating speed of the anneal section. Many other control features and operating experiences might be mentioned and described in detail. In addition to these specific items and the many others unmentioned, which provide the necessary inherent characteristics, it is felt that the performance of a system is dependent on the adequacy of its components. Much consideration has been given to selecting proved, rugged and liberally designed devices to insure a maximum of maintenance-free operation.

John Vogel: The position regulator for the free loop between the No. 2 and No. 3 bridles consists of a modulated photo-electric signal stage, a magnetic amplifier type preamplifier stage and a rotating regulator output. This line was operated for a short time with tight strip between these bridles instead of a loop. The position regulator was designed so that it could be used as a current regulator for this type of operation by simply using a current input signal instead of a position signal. Therefore the same preamplifier and output regulator could be used to supply the field of the bridle booster generator, and only the input signal has to be changed for the two types of regulation.

The position regulator at the entry tension device consisted of a variable reactor signal stage, a magnetic amplifier preamplifier and a rotating output. When it was decided not to use this tension device but rather current to regulate the No. 3 bridle, the preamplifier and output were again utilized without equipment change; and the modulated position signal was replaced with a bridle current signal.

Electronic amplifiers were kept to a minimum on this line. As mentioned previously, the photo-electric modulated loop control employs a magnetic amplifier which receives its input signal directly from the photo tube receiver units. This amplifier would typically have been electronic on earlier applications.

There is an interesting variation between the Weirton line and a new annealing line which is presently being installed at the Kaiser Steel Corp., Fontana, Cal. This line has a furnace speed of 1200 fpm with a maximum entry and exit speed of 1500 fpm obtained by generator over-voltage. This line has two free-hanging loops at the delivery end of the furnace instead of a mechanical looping tower for strip storage as the Weirton line has. A looper pinch roll supplied by a separate generator is located between the two storage loops. During normal line run these loops will be controlled by modulated photo-electric position regulators. However, when the exit end of the line is decelerated for a coil change, the

second free loop of the two will begin to lengthen and will block a photo-electric limit switch located immediately below the modulated loop control unit. As this limit switch is out, the looper pinch roll generator field is disconnected from the furnace section exciter and connected to a speed integrating magnetic amplifier voltage regulator. The auxiliary field of the looper pinch roll generator at this time will be disconnected from the loop control. The speed-integrating voltage regulator will receive speed signals from the bridles on each side of the free loop and from the looper pinch roll. It will regulate the output voltage of the looper pinch roll generator based on the speed differential between the two bridles so that the two loops will fall and rise simultaneously even during periods of coil changes.

H. D. Hughes: I would like the author's opinion on whether or not the size of the motor-generator sets used could be safely reduced in view of the fact that the load seems to be less than 50 per cent on these generators.

J. E. Butler: The load readings were taken while annealing strip 28 $^{13}/_{16}$ x 0.0117 in. The line was designed to anneal 45 x 0.015-in. strip. The line was also designed to handle 60,000-lb coils on both the uncoilers and winding reels and to accelerate form 0 to 2000 fpm in 20 sec. The full capacity of the generators is used during acceleration and deceleration. If the coil weight and/or acceleration and deceleration were reduced, the generators could be smaller.

G. M. Hunter: During the early negotiations for this annealing line, there was discussion on whether the looping tower rolls would or would not be driven. The decision was that the rolls would not be driven. I am wondering if Weirton Steel feels they would like to have them driven. Also, I would like to know how the looping tower is operated. Is it a torque motor or how is it driven?

J. E. Butler: After approximately eight months' operation at Weirton we still feel that the looping tower rolls do not need to be driven. The looping towers are operated from a hydraulic system with a pressure of approximately 500 psi. The looping towers are actuated by a high pressure, gas-hydraulic system working through two hydraulic cylinders and a cable system.

C. W. Harrison: I would like to know if you can give us the over-all load on this line.

J. E. Butler: The over-all 15-min demand has been checked at approximately 3000 kw. The major part of this load is from a-c auxiliaries with the furnace electric heaters and the main motor-generator set next in that order. ▲

TENTATIVE PROGRAM

AISE Western Meeting

HOTEL UTAH

SALT LAKE CITY, UTAH

June 15, 16, 17, 1959

Cost Estimating—Metal Working Plants, by A. J. Mosso, Executive Vice President, Auburn & Associates, Inc., Pittsburgh, Pa.

The History and Performance of the HyL Sponge Iron Process, by C. K. Mader, Project Manager, and R. Lawrence, Jr., Sales Manager, Metallurgical & Process Industries, the M. W. Kellogg Co., New York, N. Y.

Automatic Hot Strip Thickness Control—Geneva Works, by L. E. Ringger, Assistant Works Engineer, and G. S., Koss Assistant Division Superintendent, Rolling Mills, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Quality Control at Pittsburg Works Particularly Related to Flat Rolled Products, by G. A. Jedenoff, General Superintendent, Pittsburg Works, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

Improved Hearth Life of the Blast Furnaces at Colorado Fuel and Iron Corp., by John W. Carlson, Superintendent, Blast Furnace Dept, Colorado Fuel and Iron Corp., Pueblo, Colo.

Reclamation of Waste Waters at Geneva Works, by E. H. Peirce, Combustion Engineer, and R. D. Hancock, Assistant Power & Fuel Engineer, Power & Fuel Engineering, Engineering Div., Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Sintering Plant Equipment, by Gordon Baer, Manager, American Ore Reclamation Section, Koppers Co. Inc., Pittsburgh, Pa.

Hot Strip Finishing Mill Gage Control, by Hugh S. Maxwell, Application Engineer, Metal Rolling and Processing Dept., Industrial Engineering Section, and R. A. Phillips, Control Systems, Analytical Engineering Section, General Electric Co., Schenectady, N. Y.

Modernization of the Seattle Plant, by N. L. Bock, Chief Engineer, and Kenneth Grant, Electric Furnace Superintendent, Seattle Plant, Bethlehem Pacific Coast Steel Corp., Seattle, Wash.

Modern Regenerative Soaking Pits, by Henry S. Hall, Assistant Manager, Combustion Control Dept., Morgan Construction Co., Worcester, Mass.

Modern Electrolytic Tinning Line Electrical Drive Systems, by J. E. Kraske, Steel Mill Application Engineer, Metal Working Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Maintenance of Mill Oil Bearings, by C. A. Bailey, Lubrication Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa., and A. C. Cooper, Superintendent of Roll and Tool Shops, Lorain Works, National Tube Div., United States Steel Corp., Lorain, Ohio

INFORMAL STAG DINNER—JUNE 16

INSPECTION TRIP—JUNE 17

Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah.

PROGRAM

AISE SPRING CONFERENCE

Auspices of Rolling Mill Committee

THE STATLER HILTON HOTEL
BUFFALO, N. Y.

April 27, 28, 29, 1959

MONDAY, APRIL 27, 1959

8:30 am—REGISTRATION—
Mezzanine Floor, The Statler Hilton Hotel

9:00 am—ROLLING MILL SESSION—
Show Room

Chairmen: R. C. Schaefer, Assistant Superintendent, Hot Strip, Soaking Pit, and Blooming Mill Dept., Wheeling Steel Corp., Steubenville, Ohio

M. J. Cooper, Superintendent of Hot Mills, Dominion Foundries & Steel Limited, Hamilton, Ontario, Canada

"The Swedish Type of Repeater Mills for High Quality Steels" by Erik Norlindh, Morgardshammars Mek. Verkstads AB, Morgardshammar, Sweden

"Applications of Roll Ragging" by Herman E. Muller, Superintendent Roll Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"Kaiser's New Hot Strip Mill" by Lawrence L. Freret, Chief Project Engineer, Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif.

9:00 am—MECHANICAL SESSION—
New York Room

Chairmen: Charles H. Good, Jr., Chief Engineer—Central Operations, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

J. O. Dague, Superintendent, Mechanical Dept., Bethlehem Steel Co., Lackawanna, N. Y.

"A New Application for Salt Bath Treatment of Eutectoid Steel" by E. W. Stotz, Assistant Chief Metallurgist, Bethlehem Steel Co., Johnstown, Pa.

"The Use of Oil Film Bearings on a 12-In. Merchant Mill" by H. Stanley Baldwin, General Foreman, 12-In. Merchant Mill, Sheffield Div., Armco Steel Corp., Kansas City, Mo.

"Some Uses for Ultrasonics in Industry" by A. Dixon, Supervisory Engineer, Metals Joining Section, Headquarters Manufacturing Laboratory, Westinghouse Electric Corp., East Pittsburgh, Pa.

2:00 pm—ROLLING MILL SESSION—
Show Room

Chairmen: D. W. McLean, Superintendent Rod & Bar Mills, Steel Company of Canada, Limited, Hamilton, Ontario, Canada.

Fred T. Van Camp, General Night Superintendent, Wickwire Spencer Steel Div., The Colorado Fuel and Iron Corp., Buffalo, N. Y.

"High Speed–Rod Rolling" by Earle L. Chamberlain, Division Superintendent, Hot Mills, Cuyahoga Works, American Steel & Wire Div., United States Steel Corp., Cleveland, Ohio.

"Fundidora de Fierro y Acero de Monterrey-Mexico—Reports on Their New Combination Merchant Bar and Rod Mill" by B. R. Wible, Engineering Consultant to Management, and A. Fernandez, General Superintendent of Rolling Mills, Cia. Fundidora de Fierro y Acero de Monterrey, S.A., Monterrey, N. L., Mexico.

"Application and Selection of Gear Type Spindles," by Fred H. Paddon, Manager of Engineering & Sales, Amerigear/Bliss Spindles, Rolling Mill Div., E. W. Bliss Co., Salem, Ohio

2:00 pm—ELECTRICAL SESSION—
New York Room

Chairmen: R. G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

Clayton L. Squier, Assistant Electrical Superintendent, Bethlehem Steel Co., Lackawanna, N. Y.

"54 Years of Operation of the First Electric Driven Reversing Mill," by George H. Krapf, Division Superintendent, Power Production, and Elmer I. Pearson, Assistant Chief Engineer, South Works, United States Steel Corp., Chicago, Ill.

"Automatic Gage Control on Cold Rolling Mills at Dofasco" by N. D. Stephens, Electrical Superintendent, Dominion Foundries and Steel, Limited, Hamilton, Ontario, Canada

"Application of Individual Drive Motors to Mill Table Rolls" by Anthony Jakimovich, Application Engineer, Metal Rolling & Process Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

TUESDAY, APRIL 28, 1959

9:00 am—ROLLING MILL SESSION—
Show Room

Chairmen: F. G. Kredel, Chairman, Bar Mill Committee, Republic Steel Corp., Cleveland, Ohio

George A. Henderson, Superintendent, Rolling Mill Div., Bethlehem Steel Co., Lackawanna, N. Y.

"Fire Cracking in Rolling Mill Rolls," by N. R. Arant, Technical Director, Roll Manufacturers Institute, Pittsburgh, Pa.

"Mathematical Aids to Determine Bar Spread and Reduction Rates in Rolling" by Louis Moses, Mill Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Republic's Bar Mill of Tomorrow" by D. E. Weaver, Superintendent, Finishing Mills, and H. E. Berg, Chief Engineer, Chicago District, Republic Steel Corp., Chicago, Ill.

9:00 am—COMBUSTION SESSION—
New York Room

Chairmen: David Cousley, Assistant Superintendent, Utilities, Wheeling Steel Corp., Steubenville, Ohio.

E. T. W. Bailey, Chief Fuel Research Engineer, The Steel Co. of Canada, Limited, Hamilton, Ontario, Canada.

"Safe Control of a Mixed Gas Distribution System Without the Use of a Holder" by Burton D. Barns, Supervisor, Fuel and Utility Section, Plant and Production Engineering Dept., Steel Div., Ford Motor Co., Dearborn, Mich.

"High Head Alloy Slab Heating for Planetary Mill Rolling" by Oscar J. Zanatta, Utilities Engineer, Atlas Steels Limited, Welland, Ontario, Canada.

"Continuous Annealing in Molten Sodium" by J. D. Keller, Partner, Associated Engineers, Pittsburgh, Pa.

2:00 pm—OFF-THE-RECORD ROLLING MILL PANEL DISCUSSIONS—

SHAPED PRODUCTS SESSION
Show Room

Moderator: Don C. Horsman, Plant Superintendent, Continental Steel Corp., Kokomo, Ind.

Crush grinding—A potential aid to quality and service on finishing mill rolls

Effective guide programs—Design, materials, performance and maintenance

Rolling of large coils—Their design and future production and markets

FLAT PRODUCTS SESSION
New York Room

Moderator: R. P. Schuler, Manager of North Mills, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

Influence and control of hot mill bands with regard to subsequent operations—Rundown, profile, rolled-in scale, slivers, feather edge, etc.

7:00 pm—INFORMAL STAG DINNER—
Ballroom

Speaker: H. G. DeYoung, President, Atlas Steels Limited, Welland, Ontario, Canada

WEDNESDAY, APRIL 29, 1959

8:30 am—INSPECTION TRIP—

Atlas Steels Limited, Welland, Ontario, Canada, and the direct reduction plant of **Strategic-Udy Metallurgical & Chemical Processes, Ltd.,** Niagara Falls, Ontario, Canada. Buses will leave from the Statler Hilton Hotel and will be back before 5:00 pm.

Aerial view of Buffalo's business district.

ROLLING OF METALS

The independent variables which determine work roll diameter are the workpiece's surface condition, thickness-width ratio, temperature and constrained yield strength at that temperature and surface condition of the rolls . . . . for a 4-high mill, another design specification that must not be exceeded is the maximum allowable bearing pressure between the work and backup rolls, if roll spalling is to be prevented

by J. I. Greenberger, Group Engineer
United Engineering and Foundry Co., Pittsburgh, Pa.

EARLY shaping of metals had been by casting, hammering, forging or various combinations of these operations. Development of the first simple manually-operated mills for rolling sheets of gold and silver alloys quickly led to many new applications. Use of water and steam power for driving the mills greatly increased the physical size of the rolling process, and today's modern electrically-powered and electronically-controlled rolling mills are end results of a gradual evolution. It should be noted that the rolling operation was the first metal shaping process to depart from the pure handicraft processes and as such was a significant advance both from a production and technological standpoint.

The earliest mills used two cylindrical work rolls and were designated as 2-high mills. Use as one-way rolling mills, such as the original tin plate hot mills, necessitated development of a feeding means to return the rolled material to the entry side of the mill. Used as a reversing mill, the 2-high requires expensive d-c drives.

Subsequent demand for rolling wider and harder materials required greater mill stiffness to obtain an acceptable product. The 3-high mill was the first solution to this problem. Use of larger diameter backup rolls and a smaller middle roll achieved greater stiffness and drive simplification. The simpler and cheaper a-c drive is applicable to the 3-high mill since material flow direction is reversed, not by roll reversing, but by alternately using the upper and lower roll bites of the middle and backup rolls. Tilting tables on both sides of the mill are required for feeding of material alternately into the upper and lower bites.

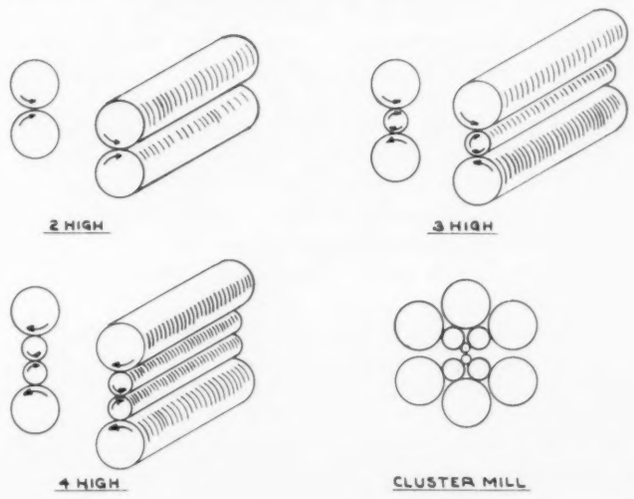
Demand for more mill rigidity led to 4-high mills in which two relatively small work rolls are each backed up by relatively massive backup rolls.

Still another mill arrangement for applications requiring rigidity is the cluster mill, wherein a cluster of intermediate and larger size backup rolls support each small work roll. The cluster mill arrangement also incorporates some horizontal support for the work roll and is most useful when very small work roll diameters are necessary or when wide mill widths and moderately small work rolls are required.

Figure 1 shows diagrammatically typical cluster 2-high, 3-high and 4-high mill arrangements.

The rolling process has many controlling and limiting factors. Work roll diameter is a prime considera-

Figure 1 — Typical rolling mill arrangements.



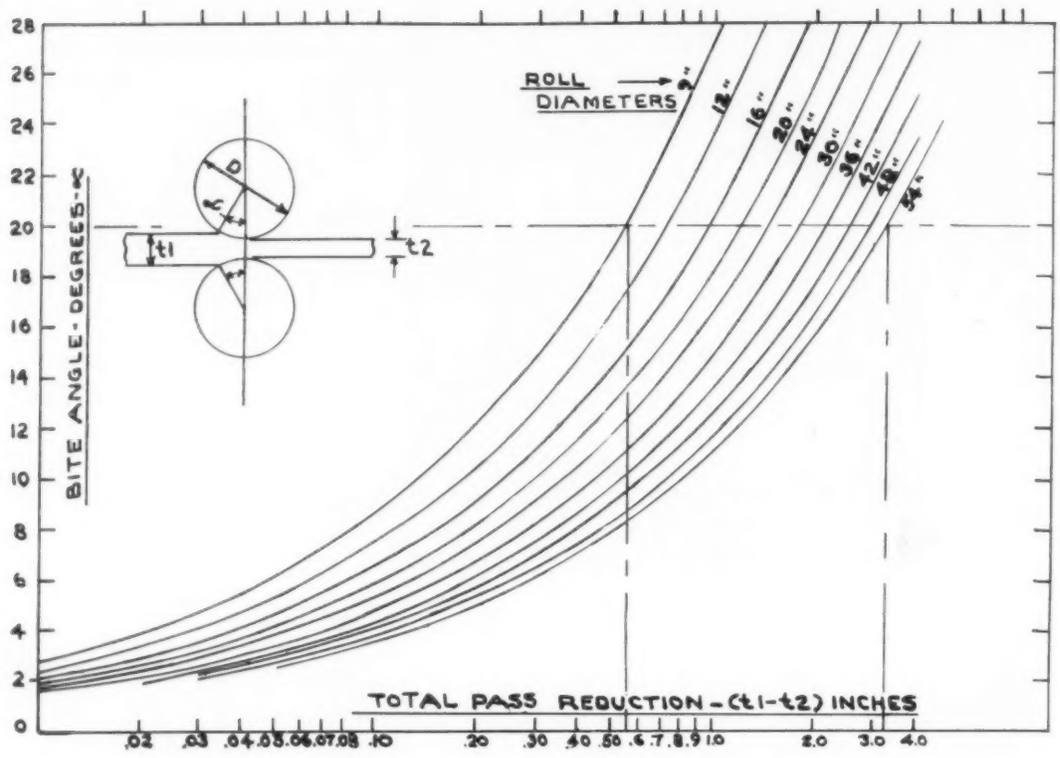


Figure 2 — These curves show roll bite angles for various reductions by work rolls of different diameters.

tion. Relatively high rolling temperatures reduced the physical properties of the material being rolled thus making it relatively easy to take large reductions. For a given roll diameter, however, the limitation of maximum permissible bite angle before slippage occurs is a controlling factor. For example, where soaked ingots are reduced as rapidly as possible in large blooming or slabbing mills, total reductions of 1½ to 2 in. or more are usually taken in the initial passes. Roll diameters of about 45 in. are used in the larger primary blooming or slabbing operations so that these reductions per pass can be taken without exceeding permissible bite angles. In the comparable hot strip mill operation reheated slabs 8½ and 9 in. thick are given total reductions up to 1¾ in. in the first roughing mill stand which has 44-in. diam rolls. Earlier hot mills had smaller diameter work rolls in the roughing stands, and pass reductions were limited by this maximum permissible bite angle. Ragging or roughing of roll surfaces and the use of auxiliary pushers are typical operating expedients to increase the maximum reduction per pass of a mill.

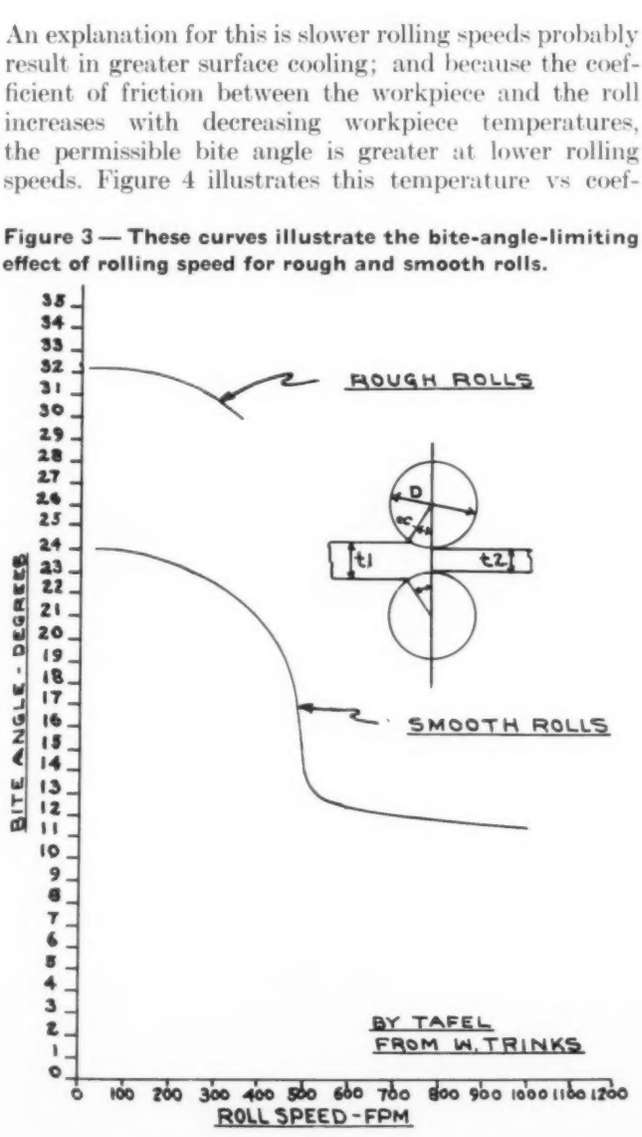
In primary blooming or slabbing mills as well as in the first roughing stands of hot strip mills, roll diameters from 36 to 45 in. are quite common. These large-diameter work rolls are selected for these applications as the result of roll bite limitation being the governing factor.

Also, there are maximum permissible bite angles for cold mills. Roll surface finish, the nature of the lubricant and the particular material being rolled also affect the allowable maximum reduction.

Figure 2 shows typical bite angle curves used for mill work roll size selections.

In hot breakdown rolling applications, in addition to work roll diameter selection for maximum reductions, speed also affects the coefficient of friction thereby limiting the allowable reduction for a given work roll diameter. This speed effect is shown in Figure 3. Note that at lower speeds higher bite angles may be used. An explanation for this is slower rolling speeds probably result in greater surface cooling; and because the coefficient of friction between the workpiece and the roll increases with decreasing workpiece temperatures, the permissible bite angle is greater at lower rolling speeds. Figure 4 illustrates this temperature vs coef-

Figure 3 — These curves illustrate the bite-angle-limiting effect of rolling speed for rough and smooth rolls.



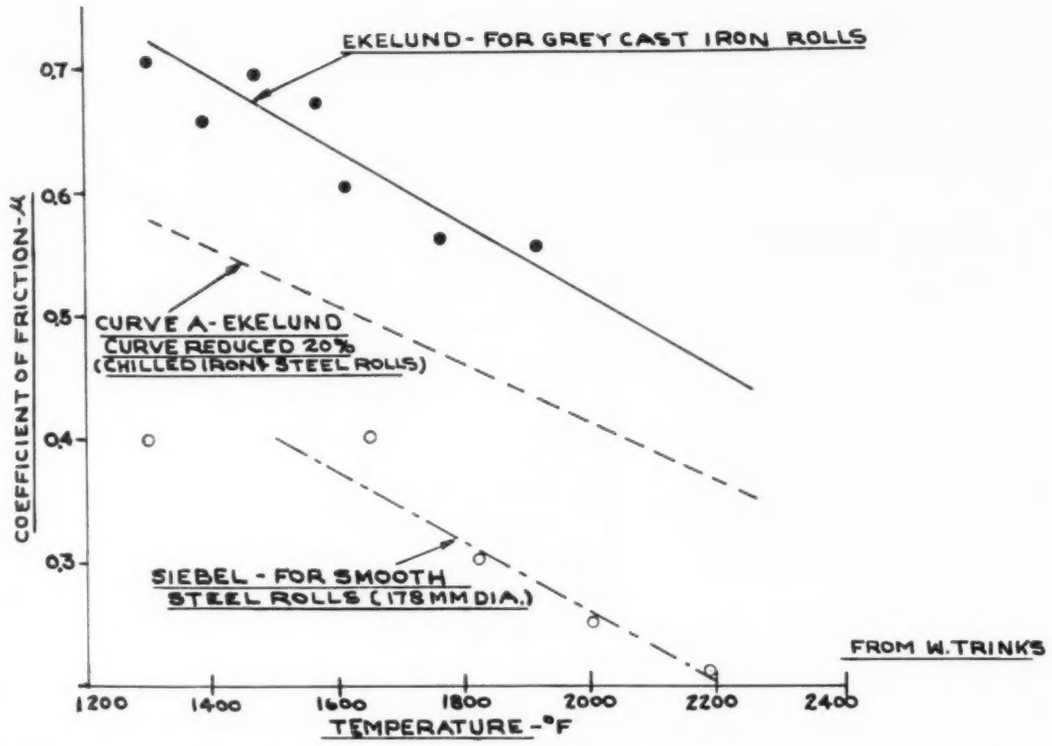


Figure 4 — Coefficient of friction between steel and rolls varies with steel temperature.

ficient of friction phenomenon. Accordingly rolling speeds below base mill speeds are usual for the first heavy breakdown passes.

After hot rolling and pickling, cold rolling reduces the strip or sheet product to the desired final thickness. Cold rolling operations introduce several new factors which affect the selection of proper size work rolls. The physical properties and the cold work hardening characteristics of the material being rolled are of prime importance. Elementary considerations in rolling are illustrated in Figure 5. In this simple idealized condition of assuming rigid rolls, each reduction corresponds to certain compression areas in the roll bite. This area times the average constrained yield strength of the material being rolled results in a definite total rolling pressure. For a given reduction, i.e., $t_1 - t_2$ constant, it can be shown that the compression area, $\bar{x}$ times w, where $\bar{x}$ is the contact chord length, is proportional to the square root of the work roll diameter for a given steel width "w." Smaller work rolls, with their reduced compression area for a given reduction, thus results in lower total rolling pressures, reduce physical requirements of mill size, etc. Another factor also enters the work roll size selection for a given schedule. Unfortu-

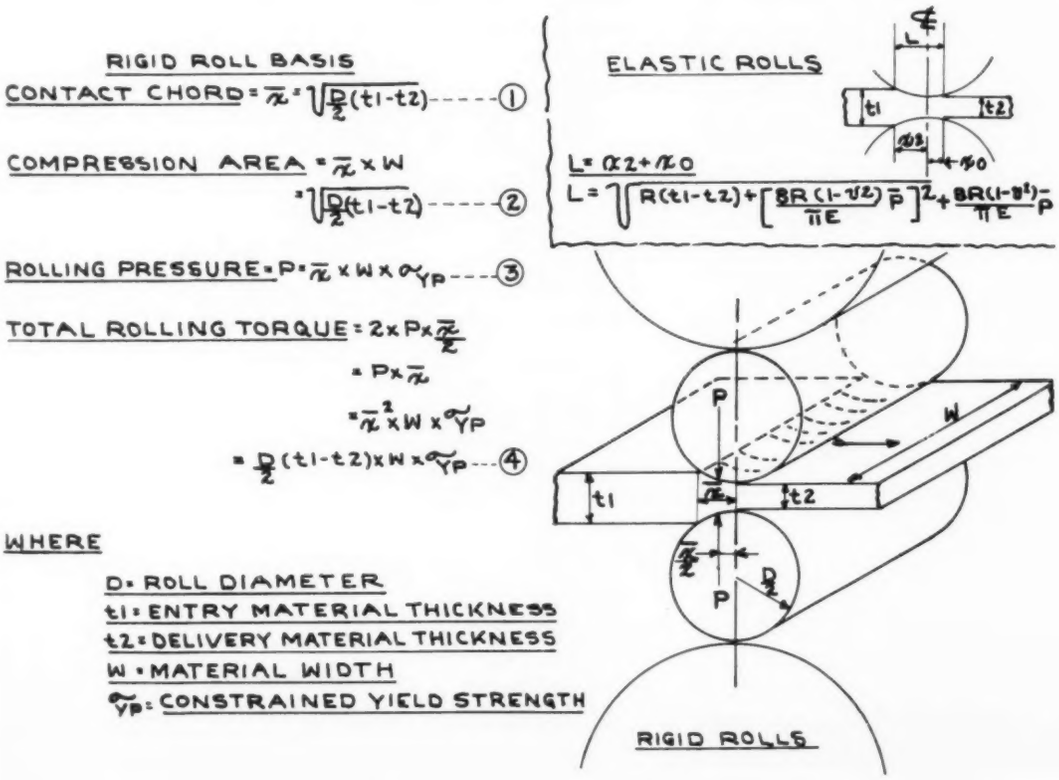

RIGID ROLL BASIS
CONTACT CHORD = $\bar{x} = \sqrt{\frac{D}{2}(t1-t2)}$ ----- ①
COMPRESSION AREA = $\bar{x} \times W$
$= \sqrt{\frac{D}{2}(t1-t2)}$ ----- ②
ROLLING PRESSURE = $P = \bar{x} \times W \times \sigma_{YP}$ ---- ③
TOTAL ROLLING TORQUE = $2 \times P \times \frac{\bar{x}}{2}$
$= P \times \bar{x}$
$= \bar{x}^2 \times W \times \sigma_{YP}$
$= \frac{D}{2}(t1-t2) \times W \times \sigma_{YP}$ --- ④
WHERE
D = ROLL DIAMETER
t1 = ENTRY MATERIAL THICKNESS
t2 = DELIVERY MATERIAL THICKNESS
W = MATERIAL WIDTH
σ_{YP} = CONSTRAINED YIELD STRENGTH
ELASTIC ROLLS
L = α2 + α0
$L = \sqrt{R(t1-t2) + \left[\frac{8R(1-\nu^2)}{\pi E}\bar{P}\right]^2} + \frac{8R(1-\nu^2)}{\pi E}P$
t1
t2
P
W
RIGID ROLLS

Figure 5 — Initial roll design calculations assume that the rolls do not deflect.

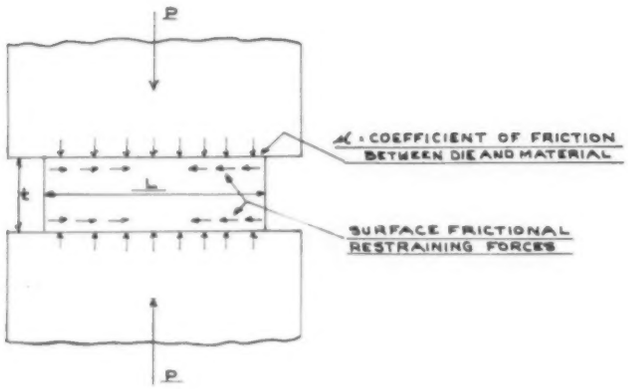


Figure 6 — The stress developed in material compressed by dies is similar to that resulting from rolling compression. The frictional forces between the workpiece and the rolls restrain flow of the workpiece material and thereby result in internal stresses in the workpiece.

nately, work rolls are not rigid and under the existing roll pressures, considerable local deformation occurs to increase the compression area. The phenomenon of work roll deformation or flattening under pressure has been thoroughly investigated and reported by Hitchcock [1].

The simple rigid roll contact chord length $\bar{x} = \sqrt{R(t_1 - t_2)}$ assumes the rather formidable deformed contact length expression:

$$L = \sqrt{R(t_1 - t_2) + \left[\frac{8R(1 - \nu^2)}{\pi E} \times \bar{p}\right]^2} + \frac{8R(1 - \nu^2)}{\pi E} \times \bar{p}$$

When hard materials are rolled, the magnitude of roll flattening becomes an important consideration. As may be verified by the above equation, smaller work rolls will show less-percentage flattening.

Strip thickness is also a factor in proper work roll size selection. The simple representation of Figure 6 indicates material of thickness "t" and width "L" undergoing compression by a set of flat dies. Frictional resistance to spread exists between the die surfaces and the material under compression. For thick material these surface frictional forces are of secondary importance when considered on a unit stress basis. For thin material, however, these same surface frictional forces result in high unit stresses in the material. The practical limit of rolling hard, thin material is established by this geometrical factor. Previous publications [2] developed a mathematical factor $\frac{\mu L}{t}$ which combines the effects of coefficient of friction "μ," the deformed contact length "L" and average strip thickness in a pass "t" to yield a pressure multiplication factor "PMF." This PMF times the constrained yield strength of the material represents its true unit resistance to compression which exists for a given $\frac{\mu L}{t}$ condition. Figure 7 indicates the importance of the PMF factor for increasing values of $\frac{\mu L}{t}$.

For the several reasons noted above, smaller-diameter

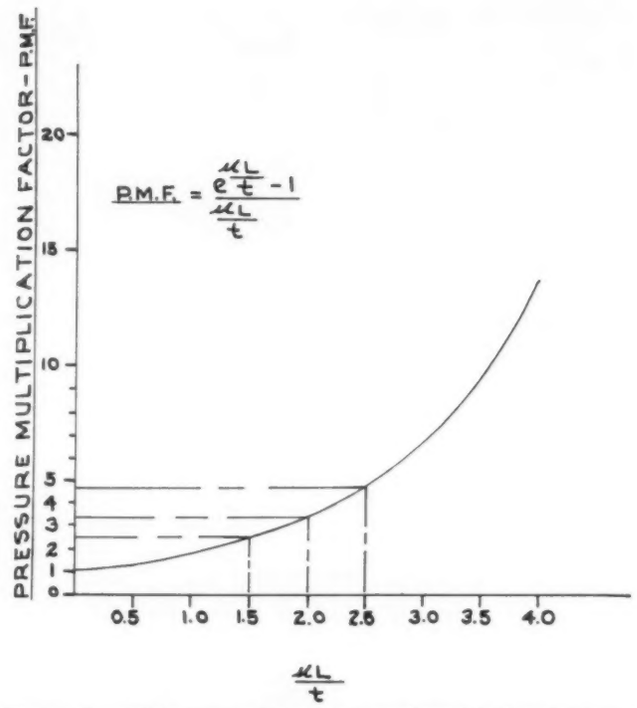
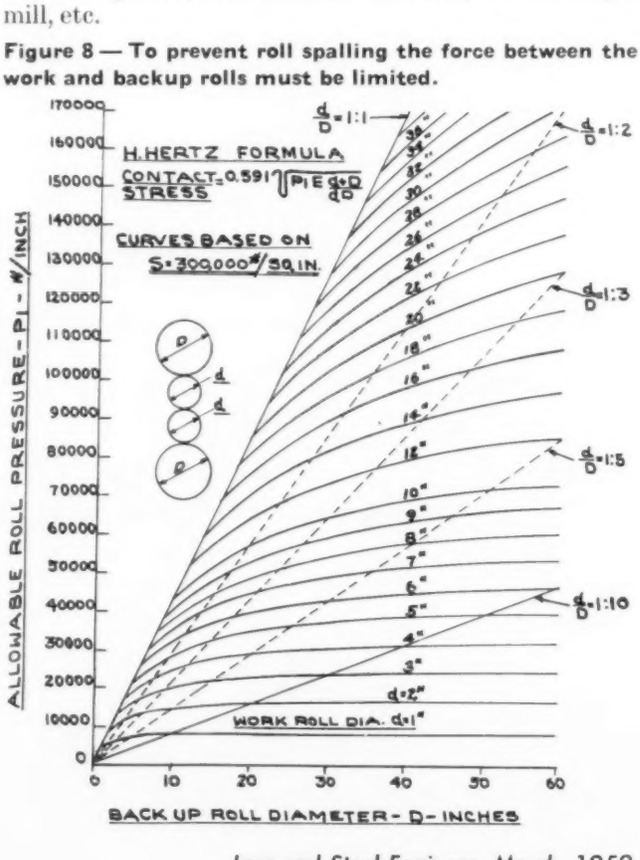


Figure 7 — This curve shows how surface friction between roll and workpiece and the ratio of material width to its thickness affect the unit pressure on the work rolls.

work rolls are used in cold mills. One should not, however, conclude that because theoretical considerations so indicate, the smallest possible work roll diameter is the proper selection. On the contrary, practical considerations result in essentially the opposite conclusion or approach to the cold rolling problem. The largest possible work roll diameters which still permit practical reductions should be selected because of their longer roll life between grinds, better strip flatness, better heat dissipation, less thermal sensitivity in the larger mill, etc.

Figure 8 — To prevent roll spalling the force between the work and backup rolls must be limited.


ALLOWABLE ROLL PRESSURE - PI - #/INCH
H. HERTZ FORMULA
CONTACT STRESS = 0.591 √(PIE d+D / dD)
CURVES BASED ON S = 300,000 #/SQ IN.
d/D = 1:1
d/D = 1:2
d/D = 1:3
d/D = 1:5
d/D = 1:10
WORK ROLL DIA. d=1"
BACK UP ROLL DIAMETER - D - INCHES

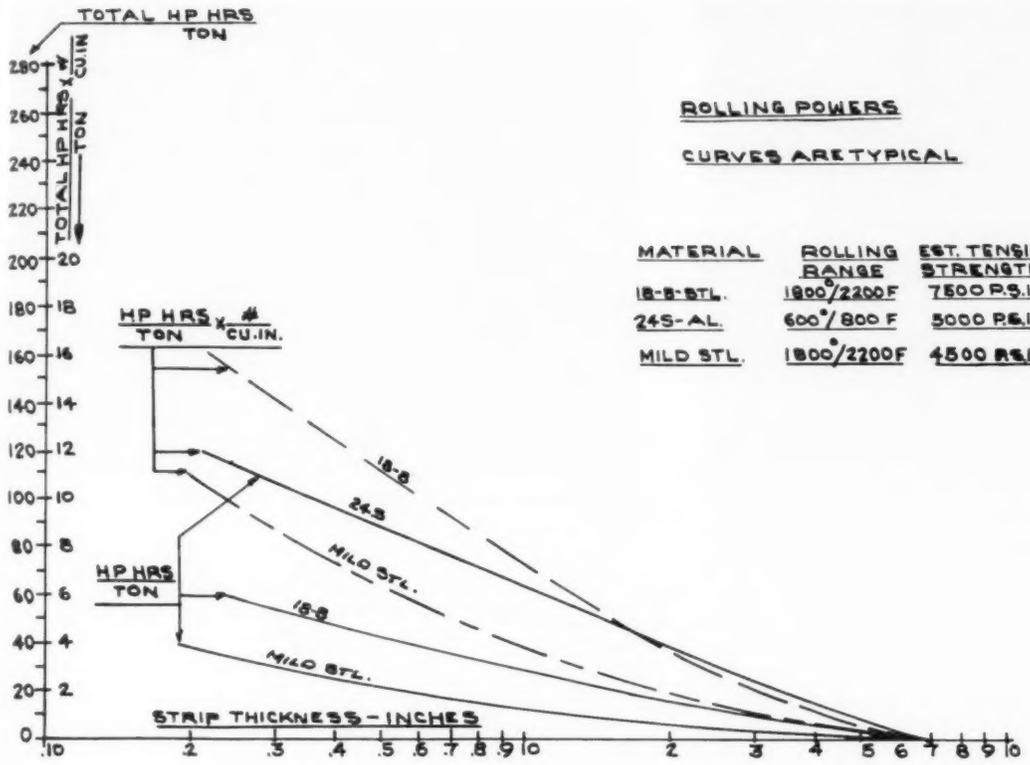

TOTAL HP HRS / TON
TOTAL HP HRS / TON x # / CU.IN.
ROLLING POWERS
CURVES ARE TYPICAL
MATERIAL | ROLLING RANGE | EST. TENSILE STRENGTH
18-8 STL. | 1800°/2200 F | 7500 P.S.I.
24S-AL. | 600°/800 F | 5000 P.S.I.
MILD STL. | 1800°/2200F | 4500 P.S.I.
HP HRS / TON x # / CU.IN.
HP HRS / TON
18-8
24S
MILD STL.
18-8
MILD STL.
STRIP THICKNESS - INCHES

Figure 9 — From this curve the rolling work or energy requirements can be determined for any reduction of these materials from seven in. or less to any final thickness.

An important practical factor in rolling mill engineering is the pressure limitation between backup and work rolls in 4-high mills. Contact stresses in the rolls, set up by the cylindrical contact between backup and work rolls, must be limited to prevent spalling. The use of the Hertz formula for stresses between cylinders is illustrated in Figure 8. Values below 300,000 psi are safe contact stresses.

The hot and cold rolling characteristics of the material being rolled greatly influence the selection of the proper rolling equipment and rolling techniques. Carbon steels, stainless steels, aluminum and its alloys, copper and its alloys, the magnesium alloys, tungsten, molybdenum, and titanium and its alloys all possess peculiar rolling characteristics which affect actual practice. Hot rolling temperatures, reduction per pass, and coiling temperatures are necessary considerations in hot rolling. Good lubrication, use of tension, proper use of intermediate anneals and similar considerations are necessary in cold rolling if the final product is to have desired physical characteristics. For cold rolling hard, thin materials, proper use of adequate strip tension is a critical factor.

Typical power curves for rolling of metals are quite interesting and are another working tool of the rolling mill engineer. Figure 9 shows a typical power curve with material thickness as the abscissa and the expression horsepower-hours per ton, as ordinate. The expression hp-hr per ton may be converted to and expressed as $hp/0.360aAV$ where, hp = deformation work of pass in hp; a = density in lb per cu in.; A = delivered area after roll bite in sq in.; and V = delivered speed after roll bite in fpm.

From established power curves it is a simple matter to determine required power for any desired schedule. It also permits predicting the power requirements of material for which power curves do not exist. This can be done because deformation work per pass is normally proportional to the yield points of the materials. Where metals of dissimilar densities are being compared, the usual horsepower-hours-per-ton curves do not show this agreement with physical properties. By multiplying this expression by the materials' density, the resultant curves are directly indicative of the yield strengths.

Among the many apparent contradictions to rolling theory is the fact that hot rolling the light or so-called weak metals, aluminum and magnesium, requires more power for the same pass reduction than ordinary carbon steels. Referral to Figure 9 substantiates that the power curves corrected for density fall into a pattern that is in reasonable agreement with the materials' tensile properties. In their respective hot rolling temperature ranges, the tensile strength of 18–8 stainless exceeds that of 24S duralumin. The duralumin properties, however, exceed those of ordinary low carbon steels. Both aluminum and magnesium hot mills are more massive and more heavily powered than the usual ordinary carbon steel mills because their tensile prop-

Figure 10 — This 45 x 115-in. 2-high slab mill needs massive members.

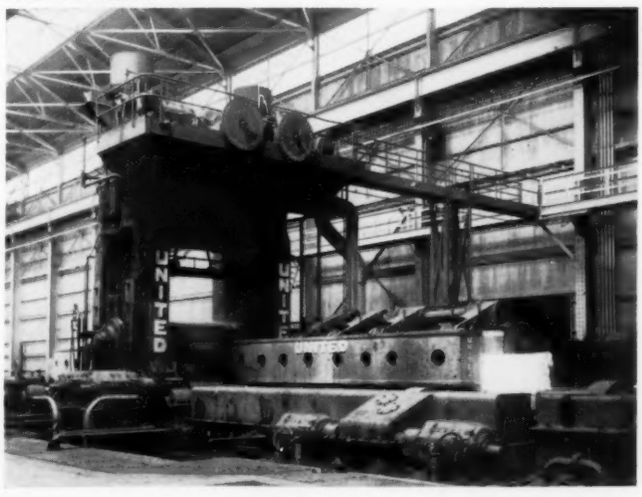


Figure 11 — A 44 x 54-in., 2-high hot strip mill roughing stand of modern design.

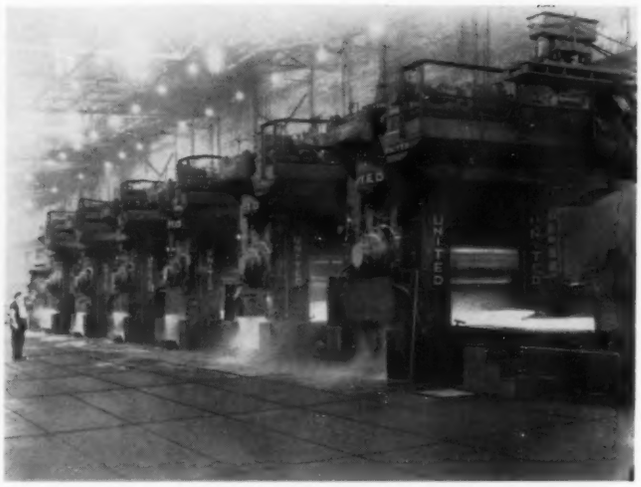


Figure 12 — This 34 & 49 x 54-in. 4-high hot strip mill finishing train gives high production.

erties are higher within their respective hot rolling ranges.

Following the step-by-step procedure of rolling ordinary carbon steel from an ingot to its final tinplate or sheet form will pinpoint actual rolling procedures. Slab ingots weigh up to 50,000 or 60,000 lb with a more usual weight of 30,000 lb. The slabbing mill proper will normally roll blooms for billet breakdowns, structural mill breakdowns and similar products. A typical large slabbing and blooming mill will be a 45 × 115-in. 2-high with each work roll directly connected by long spindles to a d-c motor. Motor sizes range between 3000 and 6000 hp per roll depending on mill size and production requirements. The mill may be a high-lift type with edge rolling passes being taken with the slabs on edge, or it may be a universal type mill with large edging facilities.

High-lift slabbing mills require massive manipulating side guards. Both types of slabbers have high-speed screwdowns so that pass-settings may be made with a minimum of delay. After the ingots have been rolled down to slabs of proper width and thickness, the hot slabs proceed along the runout tables to shears which cut them to a desired length, thence to the slab pilers and finally slab storage. Where desired, scarfing units are included in the mill line for oxygen scarfing of the slab surfaces. Otherwise some manual or semi-automatic scarfing of slabs may have to be done before the next rolling phase, the hot strip mill. The massiveness of blooming mill equipment is quite unexpected so Figure 10 is included to show just the mill area proper. Production when rolling slabs on a slabbing mill ranges between 200 and 400 tons per hr.

The latest development in rolling mills, an intensive study of fully automating rolling by card programming it, is being done to obtain maximum production and optimum quality.

The next stage of rolling is also a hot rolling process. Several basic types of hot mills are in common use. The so-called continuous hot strip mill has a series of roughing mill stands and edgers followed by a tandem finishing train. The semicontinuous hot strip mill usually has a heavy reversing rougher for the roughing breakdown followed by a tandem finishing train. As a variant to either of these mills a single stand reversing type finishing mill complete with reels and enclosing furnaces has been frequently used. After reduction to final desired thicknesses the hot strip proceeds along the runout table to be coiled. There are basic similarities in the operations of hot strip mills regardless of mill arrangement. The initial slab thicknesses which may range from 4 to 8½ in. or more are reduced in the roughing stages to between say ⅝ and 1¼ in. At this thickness the heavy strip or, more properly, plate is held until cooled to a certain temperature range before entering the finishing stands. This is essential to obtain a proper scale condition and optimum hot rolled surface. Final coiling temperatures are critical to subsequent pickling operations and final grain structure. Typical final, hot rolled thicknesses for tinplate are 0.075 to 0.085 in., and for sheet product are 0.085 to 0.100 in. Some hot mills are set to hot roll as thin as 0.048 to 0.050 in., the so-called barrel stock. Strip finishing speeds up to about 2300 fpm and coil sizes up to about 30,000 lb are typical.

An unexpected limitation in hot rolling is final minimum thickness when rollling some of the high tensile alloy or stainless groups. Typical work roll sizes in the finishing stands have ranged from 23 to 27 in. diam. The combination of these fairly large diameters with the high coefficient of friction in the last finishing stands result in a $\frac{\mu L}{t}$ factor of sufficient magnitude that only small reductions can be taken. Thus there is a practical minimum for hot rolled thickness. An interesting, recently reported development in the rolling of metals, which emphasizes this minimum thickness phenomenon, is the use of a special composite slab by one major steel producer. Recent customer requests for hot rolled, high tensile alloy and stainless steel plates in thicknesses from 0.007 to 0.187 in. and widths from 90 to 125 in. are met by completely encasing multiple plates of the desired high alloy material within a carbon steel exterior. This composite slab is then heated and hot rolled to plate form in a normal fashion. After four-side edge shearing, this composite plate is separated into its individual pieces. The desired final plate thickness determines the number and thickness of alloy plates used to form the composite slab. Reported results have been excellent. Use of smaller work rolls as well as development of a lubrication means are other available approaches for hot rolling these high alloy groups.

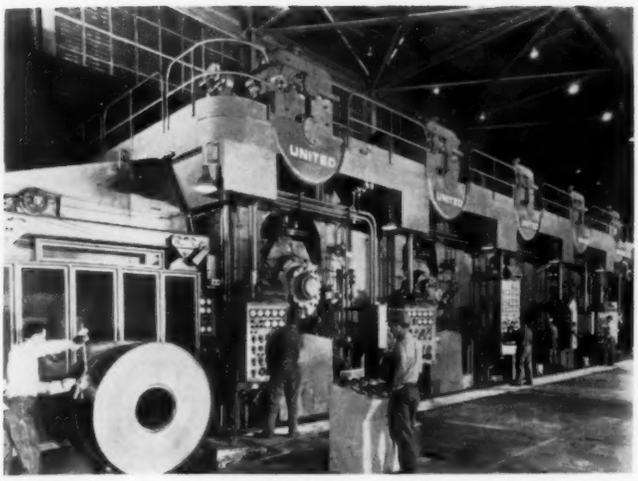


Figure 13 — Capable of handling 60,000-lb coils, this 23 & 56 x 52-in. 4-high 5-stand tandem cold mill is one of the fastest cold mills in the world.

As a practical illustration, this same strip after pickling is cold rolled on smaller diameter work-roll mills with adequate lubrication to much thinner gages. The first pass in the cold mill reduction for carbon steels may be 35 to 50 per cent whereas only 15 to 20 per cent could be taken in the last hot mill stand. Thus reduction of the friction coefficient and the use of smaller work roll diameters more than offsets the increased cold physical properties.

Figures 11 and 12 illustrate typical hot mill installations.

Cold rolling, the next rolling operation, has several functions, the first of which is to reduce the strip to the desired final thickness. Strip for tin plate is usually cold rolled to 0.0072 to 0.0124 in. in widths up to about 45 in. Since there are no particular metallurgical limitations, this cold rolling is performed at as high speeds as possible. Five-stand tandem cold mills roll at speeds above 7000 fpm, and strip for tin plate has been successfully rolled at speeds above 6000 fpm. Figure 13 shows a 5-stand tandem cold mill. Capable of handling 60,000-lb coils, it is one of the fastest and most heavily powered mills of its type.

Single-stand reversing cold mills were the first modern type of mill used for cold reduction. Multiple passes are taken on the reversing mill until the desired final thickness is obtained. A typical reversing cold mill may produce about 10 tons per hr of tin plate product. A modern 5-stand tandem cold mill can produce between 60 and 80 tons per hr of tin plate product.

For tin plate cold rolling, tandem mill work rolls are between 19 and 23 in. diam while 16½-in. diam work rolls and less are common for the tin plate reversing mill. For rolling harder materials and to thinner final gages, smaller diameter work rolls are used in both reversing and tandem cold mills. Figure 14 shows a 4 stand tandem cold mill for rolling copper and brass alloys to 0.003 to 0.004-in. thicknesses. It has 6¾-in. diam work rolls in stands three and four.

Commercial demand for stainless strip is primarily for product 0.018-in. and thicker. This strip is readily rolled on a conventional 4-high mill with 8, 10 or 12-in. diam work rolls even though the stainless group is considerably harder than the tinplate family. Where very thin gages of hard strip are to be rolled, one of the various types of cluster mills with very small work rolls

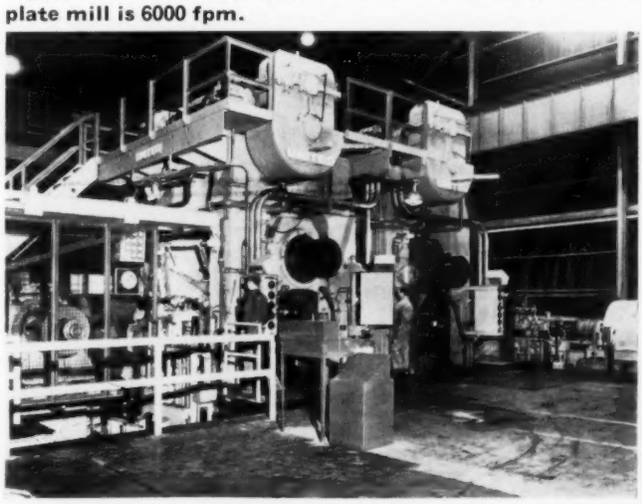
Figure 14 — This 4-stand tandem cold mill is used to roll copper and brass alloys to 0.003 to 0.004-in. thicknesses. The last two stands have 6¾ in. diam work rolls.

must be used. The governing factor is the $\frac{\mu L}{t}$ relationship.

Certain types of cold rolling are governed by metallurgical requirements. Silicon steel rolling provides an excellent example—to get a certain final grain structure and electrical characteristics, the amount of final cold rolling before annealing and heat treating must be quite carefully controlled.

For certain metals there is a final temper rolling or skin pass rolling operation performed after the cold rolled strip has been annealed. Tin plate product is a common example. To impart desired forming properties as well as a bright surface suitable for electroplating, the annealed strip is given certain amounts of cold rolling, usually in a 2-stand tandem mill. This is usually a dry-rolling operation; and to get flatness, large diameter work rolls are used. Because of the $\frac{\mu L}{t}$ factor, high rolling pressures are encountered; and quite massive 4-high mills are required. A combination tandem mill with a small work-roll-diameter, 4-high stand followed by a large diameter 2-high is also used for tin plate temper rolling. For stainless product skin passing is primarily to obtain bright surface; fairly large diameter 2-high mills are satisfactory. Figure 15 shows a 6000-fpm 2-stand tandem tin plate mill.

Figure 15 — The strip speed of this 2-stand tandem tinplate mill is 6000 fpm.



Development of better lubricants and systems of application; faster and more sensitive electrical controls; better bearings for the backup rolls, both roller and oil type; improved steelmaking and metallurgical practice; improved instrumentation and controls; added to the experience and ingenuity of mill builders and mill operators have made possible the high-speed tandem cold mills of today.

Continual demand for newer and tougher metals to meet the more stringent requirements of the coming atomic and space age promises to keep the rolling mill engineer busy for years to come.

This paper has discussed many of the basic engineering and operating problems involved in hot and cold rolling, particularly with regards to flat rolling. Some of the working tools of the rolling mill engineer have also been pointed out and discussed. In flat cold rolling the importance of tension and its effect on its ability to reduce particularly the hard, thin materials has been mentioned but not analyzed. Several excellent papers [3] cover the effects of tension quite adequately. Shape rolling is a science and an art involving many other factors besides those noted in this paper and has been adequately covered by other papers presented to the AISE.

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Discussion

PRESENTED BY

E. A. RANDICH, Mechanical Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

J. I. GREENBERGER, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

LOUIS MOSES, Mill Engineer, Bethlehem Steel Co., Bethlehem, Pa.

E. A. Randich: There are a number of questions concerning the hot rolling of stainless steel by the special composite slab method of rolling. I was wondering what type surface was produced on the stainless steel sheets in the hot mill and what sort of gage variation and flatness tolerance is obtained since the old sheet mill practice of rolling seems to be implied? Are the high tensile physical properties of this material obtained by further cold rolling or by heatment?

Now, we have found that the bulk of commercial demand for wide stainless strip cold rolled to 0.016 to 0.018 in. and thicker can be readily rolled by conventional 4-high mills with about 16-in. diam work rolls. We normally, by making use of lubricants, roll coolants, and good operations, have found that we can take from 65 to 75 per cent overall reduction between anneals and maintain our yield, quality and physical directional properties more consistently. We have also successfully rolled titanium to 0.013-in. thickness with about 50 per cent reduction on wide strips between the anneals. When one considers that the overall operating practice, i.e., the number of anneals and pickles, required for alloy steel is usually determined by surface conditions, cracked edges, overall yield, cost, quality control requirements and metallurgy rather than rolling limits we find a compromise roll size is usually dictated.

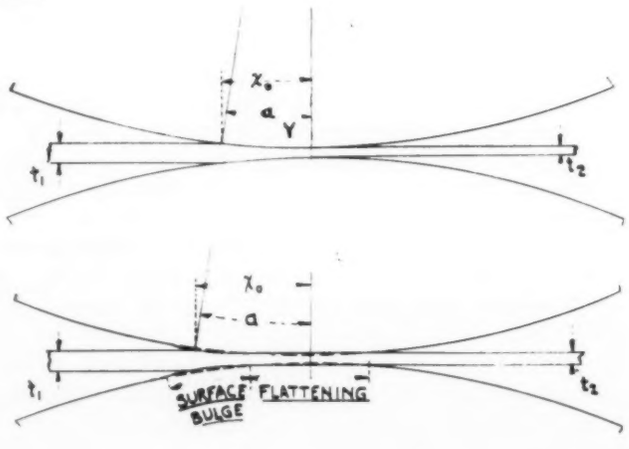
J. I. Greenberger: Mr. Randich raised several interesting questions. Hot rolling of very wide stainless composite slabs was developed by the U. S. Steel Corp. under Mr. Howard Orr's supervision as part of a program in which Air Force requirements called for very wide, thin alloy and stainless plates. These are high-tensile alloys with physicals of maybe 150,000 psi at 1000 F. To obtain this alloy material in widths between 90 and 125 in., rolling had to be done on a plate mill or some extremely wide mill. The practice developed by U. S. Steel Corp. was to take a group of ordinary hot-rolled plates of this type product, roll them as thin as possible in conventional form, and then fully encase a group of them with a covering of ordinary carbon steel plates to form a composite slab.

This composite slab would be reheated and then rolled on the same plate mill equipment to the desired thickness. When the composite plate was separated, each alloy sheet would have the correct thickness.

The rolling tolerances and gage variation would not change, i.e., if a 3-per cent gage variation existed in the alloy material in its initial state before forming the composite slab, the same percentage variation should exist after rolling the composite slab. The particular characteristics desired are high temperature, high tensile properties. This material is normally used in the hot-rolled state.

Louis Moses: The Roll Research Committee is trying to find solutions to roll spallage. There are some work rolls which, as worn out rolls at discard diameters, have withstood arduous campaigns. The elastic property of the hard surfaces on alloy chilled-iron and hardened forged-steel rolls, however low the ductility rating, is nevertheless sufficient to allow the flexure accompanying the distortion from circular to an oval cross section without, however, rupturing any of the particles at or beneath the working surface.

Figure 16 — This drawing illustrates the shape of actual roll surface distortion of typical 21-in. diam work rolls in a 56-in. 5-stand cold reduction strip mill. The top figure assumes an unrealistic rigid roll, i.e., no roll deflection; and the bottom figure is of an elastic roll, the actual case.



The effects of applying the pressures over small areas of the roll face are another matter. Figure 16 illustrates the roll gap of typical 21-in. diam work rolls in a 56-in. 5-stand cold reduction strip mill. Loadings occur at the chords X_0 which range from 0.480 in. wide when working on strip at 60 Rockwell C to 0.220 in. wide when finishing the strip at 100 Rockwell C. The bulging lines represent a continuously recurring displacement of the surface metal when roll flattening is present. Conceivably there is bulging in normal operations. Considerable modification of the schematic sketch is required if every circumstance occurring simultaneously were to be shown. No approach is made to sketch what must be a somewhat similar displacement or localized distortion at the backup roll. I would like to know if this condition leads to spalling.

J. I. Greenberger: There is no simple answer. Several things may be noted. First you show surface buildup occurring in the roll. From the laws of continuity of flow the bulge cannot be such that there is a reversal of thickness. Another comment concerns hot rolling where there may actually be a buildup of metal thickness ahead of the bite of the roll. Under the effects of high plastic pressure in the roll bite there may be actual deformation of the slab ahead of the roll bite. In Dr. Stone's paper "Rolling of Thin Strip" there is a detailed explanation of roll flattening. What you have shown in your sketch is the engineer's conception. There is a contact ahead of the geometrical center of the roll and there is also a contact after the geometrical center of the roll. The contact after is all elastic, i.e., the material does not get thin and then thicken again. It is elastically thinner at the low point, and then it elastically recovers. The limit of rolling is reached when the delivery side arc or chord is equal to that on the entry side. As to what actually occurs in the roll and just what stress pattern exists, I do not know. There have been reports, in particular one issued by the University of Illinois, covering elastic deformation and stress distribution of cylinders against flat plates and similar loading conditions. ▲

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CARL P. FARLOW, JR. was born in Alabama in 1921. He attended public schools in that state. In 1939 he joined the American Cast Iron Pipe Co. and alternately worked there and attended college. In 1943 he received a degree in mechanical engineering from the University of Alabama. He served with the Navy and returned to the American Cast Iron Pipe Co. in 1946 in the engineering department, in 1948 he joined the sales department, again served in the U. S. Navy from 1951 to 1953. He then returned to the engineering department and in 1956 was made chief engineer of American Cast Iron Pipe Co., which position he now holds.

MILTON ELWOOD MOSHIER was born in Rochester, N. Y. in 1899. He attended public schools in Rochester. He received a bachelor of science degree in economics from Colgate University in 1922 and then taught chemistry and mathematics, coached basketball and baseball at East Rochester high school for two years. In 1924 he started as a heater helper in the coke plant of Donner Hanna Coke Co., soon after transferring to the new coke plant of Bethlehem at Lackawanna, progressing to heater and general turn foreman. In 1929 he was transferred to the open hearth department and successively became third helper, second helper, and assistant superintendent, being promoted to assistant to the general manager, which position he now holds.

A. B. GLOSSBRENNER graduated from Lehigh University in 1949, following a three year interruption with the United States Air Force with service in the 14th Air Force in China. He joined the Steel and Tube Division of the Timken Roller Bearing Co. in July, 1949 and helped develop Timken's new concept of material handling for the steel industry. In 1957, Mr. Glossbrenner was made general foreman of the bloom, bar, and billet conditiong department, which position he now holds. He is the author of papers on material handling and on the conditioning of steel.

CLARE G. DIMITT, a native of Illinois, attended public schools in that state, and Armour Institute. In 1917 he joined Illinois Steel, later Carnegie Illinois Steel, and now United States Steel, South Works, working in blast furnace, maintenance, steel producing, and engineering departments as electrical leader; test engineer, chief test engineer; assistant general maintenance foreman; assistant to division superintendent of maintenance, and on technological co-ordination. He now serves as supervisor—electrical design engineering. Mr. Dimitt has been very active in AISE committee work and is a member of AISE Standardization and Research Committee and is co-chairman of the Crane and Auxiliary Drive Wiring Subcommittee.

JAMES N. EVANS, a native of Indiana, graduated from Purdue University in 1925 with a degree in chemical engineering. Until 1929 his work was primarily boiler water treatment with the Florida Power and Light Co. at several locations. From 1929 to 1937 he held various positions on power plant construction with Consolidated Edison Co. in New York City. Since 1937, Mr. Evans has been with National Tube Div. of United States Steel Corp.—for eight years at the National and Christy Park works in McKeesport, Pa., and since 1945, as superintendent, fuels and power, Lorain works, Lorain, Ohio.

HAROLD W. MOYER was born in 1914. He graduated from Ohio State in 1935 receiving a bachelor of science degree in metallurgical engineering. He then entered the employ of Republic Steel as a laboratory assistant switching to Rotary Electric in 1939, serving as chief laboratory technician and then service engineer until 1947 except for an interruption from 1942 to 1945 when he saw service in the U. S. Army as a Major in the Signal Corps. He joined McLouth Steel Corp. in 1947 and has served that company as chief metallurgist since that time.

T. G. SIMISON was born in Chicago, Ill. in 1909. He joined the United States Steel Corp., South Works, in 1926 and in 1932 moved to Inland Steel Co., serving both companies in various capacities in the plate and strip mills. In 1935 he joined Youngstown Sheet and Tube Co., Youngstown in the wide strip mill working as speed operator and roller. He was transferred to Chicago district in 1939 as superintendent of the 54-in. hot strip mill and was later promoted to superintendent of hot and cold strip mills. In 1948 he moved to Kaiser Steel Corp., Fontana, as assistant superintendent of merchant and skelp mill; in 1950 was promoted to division superintendent of rolling mills, flat rolled products. In 1951 was named assistant general superintendent of rolling mills which position he now holds.

C. W. DUNN was born in Clinton, Mass. He was graduated with a bachelor of science degree in mechanical engineering from Carnegie Institute of Technology in 1944. After service with the U. S. Navy, he started in 1946 as special engineer at the Duquesne works of the United States Steel Corp. In 1947 he was transferred to Lorain works of the National Tube Div., as a designer on the construction of No. 4 seamless mill and advanced to resident inspector on manufacturers' equipment, later joining the operating force. In 1949 he joined the Ohio Boxboard Co. in Rittman, Ohio as chief project engineer in charge of the paperboard mill expansion program. In 1951 he rejoined the U. S. Steel Corp., Fairless works as general supervisor equipment installation, became technical co-ordinator for maintenance and utilities division, and in 1955 was promoted to superintendent of utilities, the position he now holds.

A. N. REYNOLDS was born in Ridgefield, Conn. in 1916 and attended public schools in that district. He was graduated from Bucknell University in 1937 receiving a bachelor of science degree in electrical engineering. He then joined Bethlehem Steel Co., Johnstown, as a member of the "Loop" course. Upon completion of this on-the-job training was made electrical foreman of the steel car department in 1940. In 1945 he was transferred to the shell forging plant as electrical foreman; upon end of operation of the shell plant, he was appointed assistant to the superintendent, electrical department and in 1947 was appointed assistant superintendent, electrical department. In 1950 Mr. Reynolds was promoted to construction engineer in charge of the Johnstown expansion program, and in 1952 was appointed chief engineer of the Johnstown plant, the position he now holds.

RICHARD G. NOLAN was born in St. Louis, Mo. in 1921 and attended public schools in that city. Mr. Nolan spent several years in the employ of various companies including the Granite City Steel Co., Barber Asphalt Co., Koppers United Co. He served in the United States Army from 1943 to 1946. He attended Washington University from 1946 to 1950 and graduated with a bachelor of science degree in electrical engineering in 1950 After graduation from college, he was assigned to Granco, a subsidiary of Granite City Steel, as project engineer for product development In 1951 he was transferred to the company's engineering department as electrical engineer to handle construction projects and in 1956 was assigned to duties primarily in the hot rolled finishing department.

RALPH L. DOWELL was born in Onarga, Ill. in 1911 and attended public schools in that state. He was graduated from the University of Illinois 1932 receiving a bachelor of science degree in electrical engineering. After working on several construction projects, he joined the Inland Steel Co. as an electrician. In 1935 he switched to the Gary Sheet and Tin Mill United States Steel Corp. as a material expeditor. In 1937 he was transferred to the I.C.I. & R.R. Div. as an electrical engineer; and in 1939 he was moved to the maintenance department as general turn foreman—electrical in the tin mills. In 1942 he was made General Foreman-Electrical Cold Reduction and Electrolytic Tinning. In 1947 he went with Reynolds Metals Corp. as superintendent of electrical maintenance. In 1948 he returned to United States Steel, Pittsburg, Calif. as superintendent of maintenance, sheet and tin mills, being made assistant superintendent of maintenance, Pittsburg Works in 1950, and in 1957 was appointed assistant to the general superintendent, the position he now holds.

LOUIS E. RINGGER was born in 1918 in Zurich, Switzerland, and was educated in that country. After completing an apprenticeship as a mechanic and graduation from trade school, he studied electrical engineering at the Technical Institute of the Canton Zurich in Winterthur, Switzerland. In 1942 he joined the Brown Boveri Corp. in Baden, Switzerland, as test and field engineer in the relay and regulator division. From 1945 to 1948 he served as supervisor, transformer and high voltage laboratory. In 1948 he joined the United States Steel Corp., Geneva Works, as an electrical engineer and was promoted in 1955 to general supervisor, electrical engineering, and in 1958 was appointed to his present position as assistant works engineer of Geneva Works.

RICHARD F. ARMITAGE, a native of Chicago, Ill., graduated from the University of Illinois receiving a bachelor of science degree in mechanical engineering. In 1933 he joined the Republic Steel Corp., Chicago, as a lubrication engineer and also served there as combustion engineer and general millwright foreman. He served three years in the European theatre reaching the rank of Lt. Col. in the Ordnance Dept. He went to Warren as assistant mechanical superintendent in 1946 and became superintendent in 1948. In 1956 he was promoted to superintendent of construction and in 1958 was appointed to the position of general superintendent of the corporation's Warren district. He is also chairman of Republic's mechanical maintenance committee.

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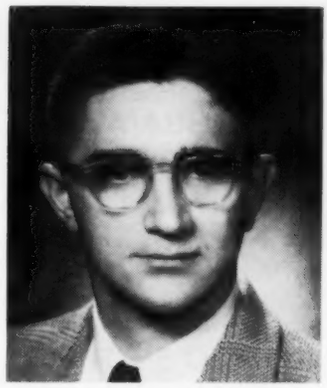
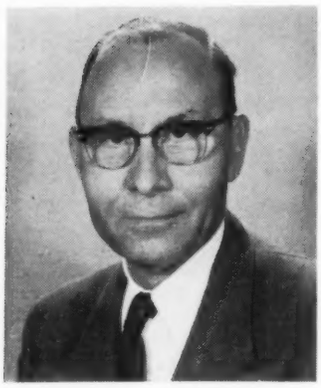
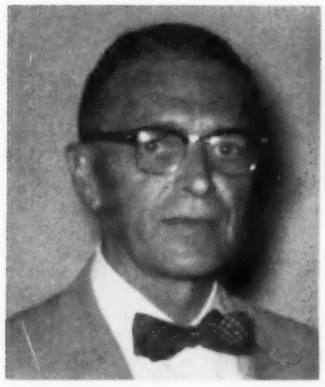
MILTON ELWOOD MOSHIER
Buffalo District Section



A. B. GLOSSBRENNER
Canton District Section



CLARE G. DIMITT
Chicago District Section



JAMES N. EVANS
Cleveland District Section

HAROLD W. MOYER
Detroit District Section

T. G. SIMISON
Los Angeles District Section

C. W. DUNN
Philadelphia District Section

A. N. REYNOLDS
Pittsburgh District Section

R. G. NOLAN
St. Louis District Section

RALPH L. DOWELL
San Francisco District Section

LOUIS E. RINGGER
Utah District Section

R. F. ARMITAGE
Youngstown District Section

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, April 27, 1959—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"R-N Operations at Spaulding" by J. S. Breitenstein, Vice President, R-N Corp., New York, N. Y.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

No April Meeting.

CANTON SECTION

Monday, April 20, 1959—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Panel Discussion on Crane Runway Design and Maintenance by Designers, Users and Crane Builders.

Merges Restaurant, Canton, Ohio

CHICAGO SECTION

Tuesday, April 7, 1959—Dinner 6:30 P.M., Meeting 7:30 P.M.

"U-Fired Soaking Pits" by Kenneth E. Dinius, Works Chief Engineer, South Works, United States Steel Corp., Chicago, Ill.

Phil Smidt's Restaurant, 1205 North Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, April 21, 1959—Dinner 6:30 P.M., Meeting 7:45 P.M.

Symposium: **"Making Iron and Steel Electrically"**

(a) **"Using Hot Metal"** by Harry W. McQuaid, Consulting Engineer, Cleveland, Ohio

(b) **"Continuous Casting"** by Dr. Harry B. Osborn, Jr., Technical Director Tocco Div., Ohio Crank Shaft Co., Cleveland, Ohio

(c) **"The (D-LM) Process"** by Robert C. McDowell, President, McDowell Co. Inc., Cleveland, Ohio

Cleveland Engineering & Scientific Center, 3100 Chester Avenue, Cleveland, Ohio

DETROIT SECTION

Tuesday, April 14, 1959—Dinner 6:30 P.M., Meeting 8:00 P.M.

Great Lakes Steel Corp. Night

Election of Officers

"Modern Trend—Sinter Plant Operation" by D. P. Cromwell, Sales Manager, Ohio District, Wm. M. Bailey Co., Pittsburgh, Pa.

Dearborn Inn, Dearborn, Mich.

LOS ANGELES SECTION

Data Not Available.

PHILADELPHIA SECTION

Saturday, April 4, 1959—Dinner 6:00 P.M., Meeting 7:00 P.M.

"Some Useful Physical Principles for Steel Mill Measurement and Control" by S. B. Prellwitz, Development Metallurgist, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

"Alan Wood Iron Powder Plant and Products" by J. W. Traub, Mechanical Engineer, and K. W. Bruland, Superintendent, Iron Powder Plant, Alan Wood Steel Co., Conshohocken, Pa.

Engineers Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Monday, April 13, 1959—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Design and Application of Programming to Automatic Reversing Mills" by W. Marshall Brittain, Manager, Digital Programming Development, Systems Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.

University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, April 29, 1959—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"General Application of Rectifiers to the Steel and Nonferrous Metals Industry" by E. J. Cham, Engineer, Power Conversion Section, and R. G. Plaisted Engineer, Metal Working Section, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

No April Meeting.

UTAH SECTION

Utah District

Saturday, April 18, 1959—Inspection Trip 8:00 A.M., Luncheon 12:30 P.M.
Inspection Trip to Coal Preparation Plant, Columbia-Geneva Coal Mine, United States Steel Corp., Wellington, Utah. Assembly 8:00 A.M., Geneva Works.

"Discussion on Coke and Coal Chemicals" moderated by George J. W. Morlock, General Foreman—Coke Plant, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Luncheon Meeting at Town Cafe, Price, Utah

Pueblo District

Tuesday, April 21, 1959—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"Conversion of Steam Locomotive Cranes to Diesel" by Owen Douglas Jones, Foreman of Scale, Hydraulic and Pneumatic Shops, Mechanical Dept., Minnequa Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

Minnequa University Club, Pueblo, Colo.

YOUNGSTOWN SECTION

Monday, April 27, 1959—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Materials Handling" by Frank B. Varner, General Transportation Manager, United States Steel Corp., Pittsburgh, Pa.

Mahoning Country Club, Girard, Ohio

Controlling Maintenance Costs

by Harold B. Maynard,
President
H. B. Maynard and Co., Inc.
Pittsburgh, Pa.

. . . . a UMS (universal maintenance standards) system can economically set standard times, which maintenance people accept as practical, for not only repetitive but also miscellaneous maintenance jobs . . . . such standards can result in as much as a 45 per cent maintenance cost reduction . . . .

THE question most frequently being asked by cost conscious managers is, "Can we do anything which will help us to better control and perhaps reduce our maintenance costs?" The ability to control depends upon the ability to measure. So the question really is, "Is it possible to measure with any reasonable degree of accuracy the great number of miscellaneous, non-repetitive, highly variable jobs that constitute maintenance work, and can we do it economically enough to make it worthwhile?"

It is a good question. Of the value of measurement and control there is no question. When maintenance work is studied and standards are established, it is found repeatedly that the typical maintenance worker takes about twice as long to do his work as the standard calls for. In other words, he is only 50 per cent efficient. When the maintenance activity is properly organized and standards are established for the jobs before they are assigned to the maintenance workers, efficiency customarily rises to 90 to 95 per cent and even higher if wage incentives are used, i.e., when maintenance work is measured and controlled, maintenance costs are reduced by roughly 40 to 45 per cent.

This is certainly worth going after, but once again the question arises, "Can the vast number of miscellaneous jobs be measured economically enough to make it worthwhile?" To find the answer, consider a factory where up-to-date measurement methods are being used. Such a company has a maintenance standards setter, a practical maintenance man, in its maintenance office. He sets standards for the maintenance requisitions that come into the office.

In the majority of cases this man can glance at a requisition and write a figure on it. This is the standard time which will be allowed for doing the work called for by the requisition. In a lesser number of cases, he will refer to one of the data manuals he has on his desk, sometimes making a few computations before recording the standard. These manuals carry craft names such as "Carpenter," "Electrician" or "Millwright." Occasionally, he picks up the telephone and talks with the person who sent in a requisition to learn more about the requirements of the work. A few requisitions he sets aside for further consideration.

In a surprisingly short time, the standards setter has worked his way through a pile of requisitions. He picks up a few he had set aside. For these he needs more information. He goes to the several departments where the jobs are to be done and discusses them with the foreman and others, occasionally making some measurements and recording some data; and at length returns to his desk.

The system which has been installed in this plant has come to be known as Universal Maintenance Standards or UMS. Four factors are essential to the success of the UMS plan. They are:

1. Proper organization of the work.
2. Properly developed work standards.
3. A qualified standards applicator.
4. Adequate training of the work force.

The first factor, proper organization of the work, includes such obvious things as planning, scheduling and dispatching, paper work routines, and the manner in which operator performance records are used for control purposes. In addition, it includes organization of the maintenance work itself. Studies of the kind and frequency of the work done by a given maintenance department will often indicate that certain kinds of work should be done on a routine preventive basis rather than when a breakdown or failure occurs. The preventive routines can be planned and standardized and can be performed at a time when a shutdown of equipment will not be required. They simplify the standards setting problem because they are repetitive in nature. Once they have been measured, the same standards apply over and over again. Thus organization for preventive maintenance is an important preliminary to the introduction of the UMS plan.

The development of work standards for the non-repetitive part of maintenance work, which is most of it, is more of a problem. Indeed it is the key to the success of efforts to control maintenance costs. Originally when industrial engineers had only time study available as a tool for work measurement, setting accurate standards was too costly to be practical. When job standards are set by individual time study, the ratio of time study men to maintenance men must be nearly 1 to 1.

Standard data or time formulas based on time study provide a better answer. But the time and cost required

to compile and apply standard data is still quite high. Even when comprehensive data are available, usually one man can set reliable standards for only 10 to 15 maintenance workers.

To get away from the high costs of development, attempts have been made repeatedly to develop standards from historical cost data. These attempts have almost always been something less than successful because of the unreliability of historical records. In some cases the control which this approach has given has proved to be better than no control at all, and worthwhile economies have been obtained. But standards based on historical data are both inconsistent and unsupported by any acceptable data and tend to be regarded as unsound by both management and the maintenance workers.

In all of these concepts, time study, standard data based on time study and even standards based on historical data, the attempt has been to develop accurate standards for maintenance work. This was a natural result of following the methods which had been used for measuring production work where, because of the repetition involved, the motion pattern and the time required to make each motion are important. So industrial engineers have sought to develop methods of setting standards which would represent the exact time required by the maintenance worker to do each job. And as a result, they inevitably became bogged down in a mass of impractical detail.

The UMS plan recognizes the fallacy in this approach. The nature of maintenance work is such that it is unrealistic to expect every maintenance worker to do a given job with exactly the same motion pattern in exactly the same time. The varying conditions of the work alone would prevent this. Practical maintenance men for years have asked industrial engineers: "How can you set a standard that will be fair for, say, a pipe repair job when you cannot tell in advance how badly the pipes will be rusted?"

The answer to this obviously is, "You can't, i.e., you cannot set a standard that will be accurate for each individual job."

In addition to varying conditions, there is another important variable that makes it impractical to strive for accurate individual standards. This is the method used by the worker. In maintenance work, the method cannot be specified motion by motion as it can be on repetitive work. Instead, to be practical, the determination of the method must be largely delegated to the maintenance man himself.

These simple concepts form the basis for a practical way to measure maintenance work. They lead to the conclusion that, instead of trying to set individual standards of pinpoint accuracy, it is more practical to set standards based upon the range of time in which a given job will probably be done by a qualified man. In effect, it can be said that a qualified maintenance worker will do a given job in, say, from 40 to 60 min, 99 times out of 100.

Once we have hold of this simple concept, we have the basis for a workable maintenance work measurement program. Its development requires the following steps:

1. The development of accurate time formulas for every type of work performed by the maintenance department.
2. The establishing of standard work groupings.
3. The establishing of bench mark jobs.

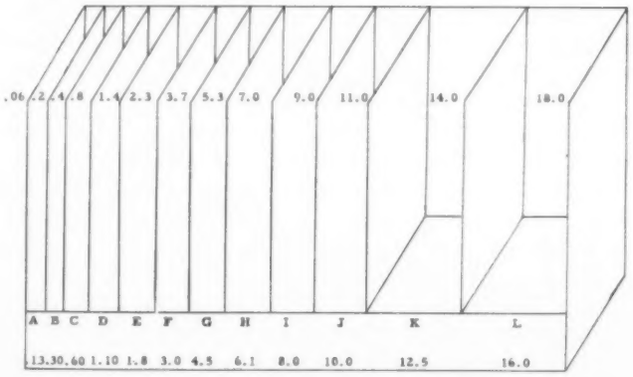
Although it is unnecessary and even impractical to strive for accuracy in the standards applied to individual jobs, it is necessary to have accurate basic data from which to work. Time formulas are therefore first developed for every type of work the maintenance department is likely to do.

If this were to be done from time study data in every factory in which the UMS plan was installed, the development of the necessary time formulas would indeed be a long and costly step. Fortunately recent developments in the field of predetermined motion time systems have helped to solve this problem. Methods-time measurement or MTM, for example, which is the predetermined time system with which the author is most familiar, has made it possible to establish standards on work which it was formerly found uneconomical to study.

It may be worthwhile to point out that there exist some misconceptions regarding the applicability of MTM to nonrepetitive work. Industrial engineers have been known to state that the technique applies only to highly repetitive, short-cycle work. Nothing could be further from the truth. MTM applies to both highly repetitive and nonrepetitive work. On high volume work, its major value is as a tool of motion study and work simplification. On low volume work, its chief usefulness is as a tool of work measurement leading to the development of time formulas. This is its value in connection with maintenance work. With MTM it is possible to develop a time formula in a fraction of the time required when time study is used.

Perhaps a brief explanation of why this is so will be of interest. When a time formula is developed from time studies, the time study man must, of necessity, study a wide range of work in order to observe and time all the elements which an operator will need to use to complete any job within the class of work to be covered by the formula. In some cases, he may have to make as many as 25 observations of certain elements under varying conditions to accumulate the data he needs, and this means that he must be on the spot when the conditions he wishes to observe occur. The MTM analyst, on the other hand, can visualize all of the

Figure 1 — The standards applicator places the job requisitions, as they come to him, in one of the pigeon holes of this figurative file. This file simply separates the requisitions by their approximate time requirements, or standard work groupings, A, B, C, etc.



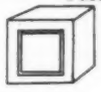
TASK AREA:	OBJECTS, MISCELLANEOUS, SPRAY		
Group A Allow .13 hr. Range .06 hr. .2 hr.	B Allow .3 hr. .2 hr. .4 hr.	C Allow .6 hr. .4 hr. .8 hr.	D Allow 1.1 hrs. .8 hr. 1.4 hrs.
Waste basket, inside and out, fair surface, one coat PT-160 .05 hr. Tote box, 12" x 6" x 24" inside and out, good surface, one coat PT-173 .06 hr. Tote box, 12" x 12" x 24",	Metal Clothes Locker 15" Wide 22" Deep 67" High Fair Surface One coat Exterior only PT-165 .24 hr.	Clothes locker, metal 22" x 15" x 67", fair surface, paint exterior and interior, one coat. PT-168 .50 hr.	Refrigerator, 8 to 10 cu. ft. capacity, 3 coats PT-172 1.0 hr.
inside and out, good surface one coat PT-161 .10 hr. Drinking fountain, 15" x 15" x 35", good surface one coat PT-162 .12 hr.	Drinking fountain 15" x 15" x 35", fair surface, 2 coats PT-164 .21 hr.	Blackboard, 4' x 8' 3 coats blackboard paint and varnish frame, one coat PT-170 .61 hr.	
Safe Fair Surface  One Coat Exterior Only PT-163 .15 hr.	Safe, exterior 5' x 2' x 2', fair surface, one coat PT-166 .28 hr.	Refrigerator, 4 to 6 cu. ft. capacity, good surface, 2 coats PT-167 .41 hr. or poor surface, 3 coats PT-171 .74 hr.	
		Refrigerator, 8 to 10 cu. ft. capacity, good surface, 2 coats PT-169 .54 hr.	

Figure 2 — To aid the standards applicator in estimating time requirements for a requisition, a number of bench mark jobs for each craft has been assembled into a complete manual.

conditions which are likely to occur and can visualize the methods that will be used for coping with them. He can thus establish elemental times without having to wait for and then observe and time the occurrence of each condition. The saving in time is great. For example, several man-days of time study are required in order to establish data for chucking and truing up parts in an engine lathe. A competent MTM analyst can accomplish the same result in about four hours.

Of course, MTM is not the only work measurement procedure used in the development of maintenance time formulas. Work sampling is used to determine allowances. Time study is used to time machine or process time. We have commented upon the relationship of MTM and time formulas, however, because together they have been essential in the development of procedures for controlling maintenance costs.

When time formulas are available, they can be used to establish standards on the vast majority of maintenance jobs in any plant. To use them for the daily task of establishing standards, however, where an individual standard would be computed for each job would be time consuming and impractical. There are just too many standards to set.

Studies of maintenance work will almost invariably show that about 80 per cent of maintenance jobs require less than eight hours to perform. These numerous short jobs cause the real standards setting problem. Time formulas can be used economically to establish standards for the long, important jobs, but something quicker is needed for the unimportant but numerous short jobs. The answer is to develop what we call standard work groupings. Using this device, an applicator can establish a standard in about two min on the average. He thus is able to establish standards covering from about 50 to 60 maintenance workers.

The idea behind the standard work groupings concept may be grasped from Figure 1. The sketch shows a number of pigeonholes, A to L, inclusive. Each pigeonhole represents a range of time. The total range covered by all the pigeonholes is from 0.06 to 18 hr. Pigeonhole A is for the range from 0.06 to 0.2 hr. Pigeonhole D is for the range from 0.8 to 1.4 hr, etc.

The task of the standards applicator is to take the requisitions that come to him for maintenance work and place them in the proper pigeonhole. He does not attempt to say exactly how long it will take to do a given job. He merely says that it will take, for example, from 0.8 to 1.4 hr to do a particular job so he places the requisition in pigeonhole D. He does not do this literally, of course, but he accomplishes the same thing when he decides that the job is a class D job.

It is impractical to assign a range of time as a standard, so he uses the average of the range. The time values he uses are shown below the pigeonholes on the sketch. For a class D job, the time value assigned would be 1.1 hr.

The pigeonholes illustrated by the sketch are those which were established for a specific installation. The classes and time ranges might be different for another installation because of different conditions. The principle followed in establishing standard work groupings is that the intervals or ranges should be sufficiently long so that it will not be difficult to place a given job in its proper classification, and yet short enough so that this method of measuring performance is reasonably accurate over a week's period.

With standard work groupings established, the next step is to establish a number of bench mark jobs to guide the standards applicator so that he will be able to place any job in the correct pigeonhole. A typical example of bench mark jobs for the craft of painting is shown in Figure 2 which covers only spray painting of miscellaneous objects in standard work groupings

TASK-TIME STANDARD No. PT-163

DESCRIPTION: OBJECTS, MISCELLANEOUS, SPRAY Spray Paint Exterior of 2' x 2' x 2' or 1 2/3 x 2 1/2' x 2' repaired safe including the prime coat to the damaged area.

REFERENCE	OPERATION	UNIT TIME	NO. UNITS	TOTAL TIME
PWP-29	Sand surface	.0026	21.5	.056
PWP-42	Mask and unmask lock and handle	.0168	2	.034
PWP-39	Prime coat damaged area	.0021	1	.002
PWP-29-5	Sand primed surface	.0026	1	.003
PWP-39	Apply 2nd prime coat to damaged area (per sq. ft.)	.0021	1	.002
PWP-29-5	Sand 2nd primed surface (2nd) damaged area	.0026	1	.003
PWP-39	Apply finish coat on complete surface (per sq. ft.)	.0021	21.5	.045
	Note: Time includes two sizes of safes as follows: 24" Height, 24" Width, 24" Depth = 50% and 27" Height, 20" Width, 30" Depth = 50% Material Handling Included in Spray Painting Time			
Total				.15

Figure 3 — The time standards for the bench mark jobs were established by incremental analysis of the operation as shown here for spray painting a small safe.

A, B, C and D. It is one page of a complete application manual for the craft of painting.

Here is the way it is used. Assume that a standards applicator is using the sheet to help him set standards on painting work. He receives a requisition calling for painting a safe 2 ft wide, 2 ft deep and 5 ft high. He looks at the sheet and sees that this particular job is listed as a bench mark job. It is bench mark job PT166 in group B so the job belongs in the B pigeonhole and would receive a time standard of 0.3 hr.

Now assume that the next requisition calls for repainting a three-drawer type metal file cabinet which is in "fair" condition. There is no bench mark job just like this on the sheet you have before you. The standards applicator therefore considers the key features of the job to be done and looks for a bench mark job with similar key features. First, he considers the surface condition of the article to be painted because this will affect the sanding and cleaning time. Next, he considers the number of square feet of surface to be painted. This not only affects painting time but surface preparation time as well. He then looks for a bench mark job where the surface condition and size are about the same as the file cabinet. He knows from experience that a file cabinet is about the same size as a clothes locker. The sheet lists as a bench mark job painting a clothes locker with a fair surface condition. This is a B class job so painting the metal file cabinet will be a B class job. A B class job carries a standard of 0.3 hr so this is the standard the applicator establishes.

Actually it takes more time to describe the mental process the applicator goes through in establishing a standard than it does for him to come up with the answer. As a matter of fact, he will be able to classify items like this from memory after he has gained some experience in working with the data and will not even have to refer to the sheets of bench mark jobs in many cases.

Now what about the bench mark jobs themselves? How are the standards for them established? This is where the time formulas make their contribution. On the sheet of bench mark jobs, one of the tasks listed was the spray painting of a small safe. The actual time value was 0.15 hr. Figure 3 shows how that task time was developed.

This is the actual calculation sheet used in developing the time required to paint a small safe. Actually, two safes were studied, one 2 x 2 x 2 ft and the other $1\frac{2}{3}$ x $2\frac{1}{2}$ x 2 ft. The number assigned to this task is PT163. This designates that this was the 163rd painting task time developed. The description of the job is "Spray paint exterior of repaired safe including prime coat to the damaged area."

The columns across the top of the calculation sheet are headed: Reference, Operation, Unit Time, Number of Units and Total Time. The reference number indicates the source of the time value. PWP29 refers to a time formula covering all cleaning and surface preparation operations. The first operation is "Sand Surface." The unit time for this operation is 0.0026 hr. The number of units involved are 21.5. The unit, in this case, is square feet of surface. The total time is simply an extension of the unit time by the number of units, or 0.056 hr.

The time for performing each of the other operations is obtained from other time formulas in a similar manner. The total time for this task is the sum of the times for each operation. The total is 0.15 hr.

Now, in order to trace back the development of this task still further, let us take the first operation listed on the calculation sheet and see where this time value came from and how it was developed. The operation is "Sand Surface" and the unit time is 0.0026 hr. The reference column tells us that it came from time formula PWP-29. Figure 4 gives data for the calculation. Figure 5 is the work sheet or method analysis chart. It is numbered PWP-29-1 and consists of tables giving times for sanding, wiping, brushing and scraping. Since we are interested in sanding times, we look under the first table. In this case, no ladder or scaffold is required so we further narrow it down to the last column of the first table. Since the safe was in "fair" condition, i.e., it only has to be partly sanded, we use the time value for the middle row. This we can see is 0.0026 hr per sq ft, the same time that appeared on the calculation sheet. This is where the time value came from. But to answer the final question of where did this table come from, we will have to go back one more step.

Figure 5 consists of an MTM analysis of the element "Sand Surface, Fair (Partial coverage)." The time for this element comes out to 0.0021 hr per sq ft. This is at the bottom of the figure. If you will now look back to Figure 4, you will notice that the first column of the table, the one headed "Basic Times," contains this same value, 0.0021 hr, for "Fair" surface conditions. You can see now how this value was developed. The value that we used on our calculation sheets, however, was 0.0026. This value consists not only of the basic sanding time but the setup time as well. The setup time includes the time to get the sandpaper, sweep the floor after the sanding is completed, dispose of the sweepings and so on. The setup time amounts to 0.0005 hr per sq ft. This time added to the basic time of 0.0021 gives the time that appears in the table for "Basic Time Plus Setup, −0.0026 hr."

How it was possible for the maintenance standards applicator to establish sound standards so rapidly can now be understood. He was, in effect, putting the requisitions for maintenance work into the appropriate pigeonholes. He was able to do much of this without

TABLE PWP-29-1 Formula PWP-29

Sanding, wiping and brushing, scraping times per sq. ft. of any surface at various conditions. Basic Times and Basic Times plus Setup Times.

TIMES PER SQ. FT.

SURFACE CONDITION	SANDING			WIPING, BRUSHING			SCRAPING		
	Basic Times	Basic Times Plus Setup		Basic Times	Basic Times Plus Setup		Basic Times	Basic Times Plus Setup	
		Ladder or Scaffold	No Ladder or Scaffold		Ladder or Scaffold	No Ladder or Scaffold		Ladder or Scaffold	No Ladder or Scaffold
Bad (Complete coverage)	.0030	.0040	.0035	.0008	.0018	.0013	.0041	.0051	.0046
Fair (Partial coverage)	.0021	.0031	.0026	.0004	.0014	.0009	.0020	.0030	.0025
Good (Minimum coverage)	.0006	.0016	.0011	.0002	.0012	.0007	.0010	.0020	.0015

NOTE: On jobs where more than one operation can be done concurrently, apply "Basic Times Plus Setup" from above table, to the first operation; apply "Basic Times" to the other operations and total to obtain time required for the job.

Figure 4 — The standard time for the "sand surface" element in Figure 3 was established from a time table, PWP-29, reprinted here.

referring to written data because of his experience with the procedure. Whenever he was not sure where a requisition should go, he referred to his bench mark data. If this gave him no help, he could go back to his time formulas and compute a new standard which he could then, if he wished, add to his list of bench mark jobs for future reference. In this manner he was able to dispose quickly of 80 per cent of the requisitions. At the same time, the standards he set were sound standards, standards which could be traced right back to the motion patterns on which they were based if anyone wished to question them.

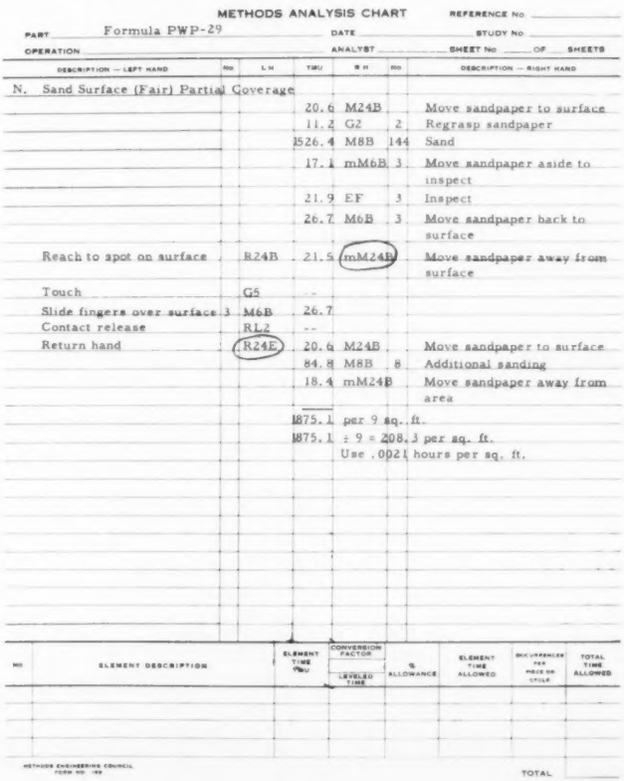
Other facets of the UMS plan are such things as how you handle travel time to the job where distances vary greatly, preparation and cleanup time, how you set a standard for a repair job when no one knows what is wrong at the outset, etc. Sound answers have been developed for all of these problems.

There are a few other points which should be stressed before the final conclusion is reached. On work as varied as maintenance work, computing performance on an individual job basis is not practical. If, however, all the total of the standards allowed for all the jobs worked on during a pay period are checked against the hours worked, a measurement of performance is obtained which is sufficiently accurate for control purposes and may even be used as a basis for wage payment if this is desired. This is true of either individuals or groups. Whether the individual basis or the group system is preferable will depend upon the conditions prevailing at a given installation.

It should be evident by now that a qualified applicator is necessary for the success of the installation. He must not only understand his data and the UMS procedure well, but he must also have a thorough knowledge of the maintenance work on which he is setting standards. He must be, in effect, a practical maintenance man himself, able to visualize how any job within the crafts he handles will be done. Without the necessary staff of qualified applicators, a UMS installation should not be attempted. Usually it is possible to find men within the maintenance group itself who have the necessary understanding of maintenance work and who have the intelligence and temperament to handle the application work satisfactorily after a period of thorough training.

So there remains only the maintenance workers themselves. How do they take to this plan? Experience has shown that they find it fair and acceptable if it is properly introduced to them. In the first place they must understand it thoroughly. As we have seen today, the plan is not particularly complicated but it does involve a number of steps and concepts. They must be carefully explained, but they make sense to practical men. Indeed the fact that the plan recognizes that it is impossible to set exact standards on work which the men themselves know from experience is quite variable is a strong selling point to both the maintenance workers and their foreman. It appeals to practical men as being a practical approach.

Figure 5 — The work sheet or method analysis chart for calculation of the standard unit time for "sanding, fair (partial coverage)" in Figure 4.



METHODS ANALYSIS CHART

PART Formula PWP-29 DATE STUDY NO

OPERATION ANALYST SHEET No OF SHEETS

DESCRIPTION — LEFT HAND	No	L H	TMU	R H	No	DESCRIPTION — RIGHT HAND
N. Sand Surface (Fair) Partial Coverage						
			20.6	M24B		Move sandpaper to surface
			11.2	G2	2	Regrasp sandpaper
			526.4	M8B	144	Sand
			17.1	mM6B	3	Move sandpaper aside to inspect
			21.9	EF	3	Inspect
			26.7	M6B	3	Move sandpaper back to surface
Reach to spot on surface		R24B	21.5	(mM24B)		Move sandpaper away from surface
Touch		G5	--			
Slide fingers over surface	3	M6B	26.7			
Contact release		RL2	--			
Return hand		(R24E)	20.6	M24B		Move sandpaper to surface
			84.8	M8B	8	Additional sanding
			18.4	mM24B		Move sandpaper away from area
			1875.1	per 9 sq. ft.		
			1875.1	÷ 9 = 208.3 per sq. ft.		
				Use .0021 hours per sq. ft.		

NO	ELEMENT DESCRIPTION	ELEMENT TIME TMU	CONVERSION FACTOR	LEVELED TIME	% ALLOWANCE	ELEMENT TIME ALLOWED	OCCURRENCES PER PIECE OR CYCLE	TOTAL TIME ALLOWED

METHODS ENGINEERING COUNCIL FORM NO. 150

TOTAL

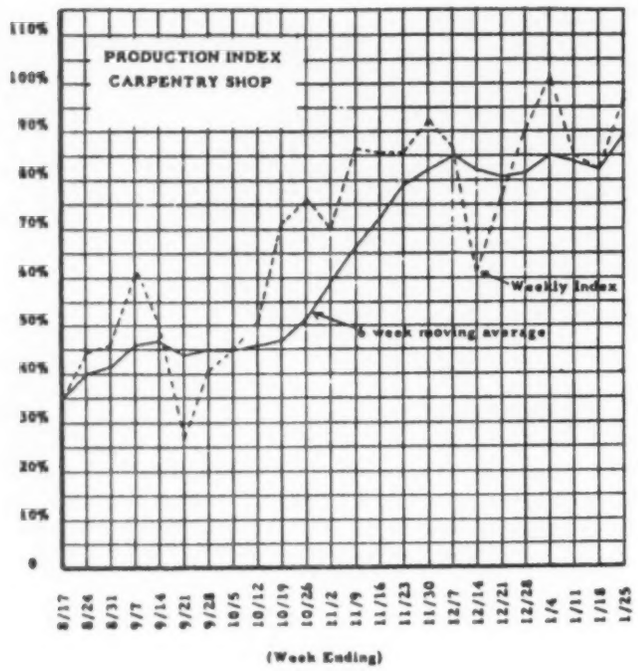


Figure 6 — This performance vs time curve illustrates how maintenance costs are reduced after UMS is initiated. In this particular case, the system was installed August 17.

In addition to explanation, a certain amount of preliminary training of the maintenance workers is necessary if the installation is to be a success. An important principle of management is "If you delegate, you must educate." Since the determination of method is left largely to the maintenance worker, training is necessary to insure that he follows a method reasonably close to the one on which the standard is based. Many maintenance workers are found to have had very little formal crafts training. They are ingenious and reasonably able, and given time can get almost any job done. But they can get it done much more quickly if they are given training in how to diagnose the problem, how to plan the work, and how to use their tools and equipment to the best advantage. Experience has shown that in most installations, preliminary training of the maintenance workers is a prerequisite for success.

Finally, what happens when standards are applied to maintenance work? Are costs actually controlled and even reduced? Figure 6 is an actual case history. It shows the performance for a group of carpenters from the time that standards were first applied until they reached what was considered to be satisfactory performance. Standards were introduced the week ending August 17. The performance for this week was 35 per cent, i.e., if the standard for a job were 10 hr, the group was taking about 28.5 hr to do it. This is a performance of 35 per cent.

When standards were available, the performance of the group was computed at the end of each week by dividing the total time allowed for the jobs completed by the actual time worked on those jobs. The results were then plotted on a curve, Figure 6. To iron out weekly fluctuations and make the trend more evident a curve was also plotted showing a six weeks' moving average of performance. As you can see, performance increased steadily. By the end of January, six months after the standards were first applied, performance had reached a level of about 90 per cent. A job with a standard of 10 hr was then being completed in about 11 hr. This is a reduction in cost of more than 50 per cent.

This is the kind of result that is obtained when maintenance work is organized properly, operators are trained in good methods, reasonable performance targets are set and steady application to the work is encouraged by competent supervisors. Basically these results are not obtained because the people work harder but because they work more steadily and more effectively.

It has been said that "A worker is just as efficient as management plans for him to be." Management has generally done an excellent job of planning for the efficiency of its productive workers, but by and large, it has not planned as well for its maintenance workers because techniques which would make this planning relatively easy and inexpensive were not available. Recent experience has shown that UMS today makes it possible to plan for the efficiency of the maintenance activity so that effective control of maintenance costs results.

Discussion

PRESENTED BY

ROBERT A. HARDERS, Chief Plant Industrial Engineer, National Works, National Tube Div., United States Steel Corp., McKeesport, Pa.

HAROLD B. MAYNARD, President, H. B. Maynard and Co., Inc., Pittsburgh, Pa.

Robert A. Harders: As you probably know, in the past most of the steel companies have what is termed assigned maintenance people as well as shops and central maintenance. Did you have in mind the applications of these standards more to the shops and central maintenance function rather than to the assigned maintenance function? In other words, would your thinking apply to the assigned maintenance people? Do you feel that through the use of these techniques we might eliminate assigned maintenance people by scheduling and controlling a maintenance force which moves out on call to do jobs and does not stand by waiting for them to develop? I would be interested in what you think about that.

Harold B. Maynard: The UMS procedure, has been applied to the type of work you speak of, with two results. First, when the work done by the assigned maintenance workers is studied, the methods for performing it are analyzed; and standards are eventually developed by which you will find that the assignment loads can usually be changed. Often it will be found that it is necessary to have as many people assigned as was formerly thought necessary. Better methods, more factual information on the maintenance requirements of the area and the like will make possible reduction of personnel and a corresponding reduction in maintenance costs. Second, where the number of assigned people is small, it quite often proves more desirable after analysis and study to do just what you suggest, namely to have the maintenance work done by control maintenance people who are dispatched to the area whenever trouble occurs. ▲

by George J. Meng,
Industrial Engineer, Alan Wood Steel Co., Conshohocken, Pa.

Evaluation of Soaking Pit Requirements for an Expansion Program

. . . . soaking pit requirements can be determined for a future ingot capacity expansion, and a reduction in the "nothing hot" delays of primary rolling mills can be realized for existing ingot producing facilities by making a thorough study of present soaking pit practice and control . . . .

A PREREQUISITE for any contemplated change in the flow diagram of a primary rolling mill must by necessity encompass a complete and thorough study of all the various factors involved. The ability to establish and maintain a balance between the supply of ingots from the open hearth; the charging, heating and drawing cycles of the soaking pits; and the rolling requirements of the rolling mill itself are indeed complex operating problems.

Many factors must be taken into consideration and correlated with the fluctuations of the steel-producing, furnace-tapping schedules, the number and type of ingot molds available, the number of buggies available, the stripping time required, and the time demanded for transportation of the ingots to the soaking pits. Many variations are found to exist when comparing one plant with another. It will suffice to say that each operation must be studied and evaluated on the basis of its individual facilities and requirements.

In addition to the desire for development of a more efficient operation of our existing facilities, the current study was also instituted to determine what added heating requirements might be necessitated by the proposed expansion program. It was acknowledged that an increase of approximately 16 per cent in ingot tonnage availability had to be matched in soaking pit capacity. On the other hand, any additions to the existing soaking pits would entail a heavy capital expenditure which, in turn, would have to be economically justified.

Past experience has clearly indicated that the installation of additional pits alone does not necessarily eliminate the need for correlation of all the other fundamentals of good operating practice. The bunched tapping of heats at the open hearth is probably the most glaring example of a common cause of unbalanced soaking pit operations and must therefore always be taken into consideration in the search for more economical scheduling of heating requirements.

Heating delays, regardless of their origin, have a profound effect on the producing capacity of the rolling mill and also on the quality of the product produced. Constant diligence is demanded of the operators to meet the many ramifications of supplying a relatively constant mill operation with a charging cycle that varies to a considerable extent.

Mill delays can and do increase the burden of responsibility of the operators to maintain the heating balance to a level which holds "nothing hot delays" to an acceptable minimum. Likewise any delay manifested during the charging cycle, such as encountering sticker ingots, tends to increase the total heating cycle time which in turn readily adds to the "nothing hot delays" and associated loss of producing capacity.

As may readily be seen from a study of this type, no single major factor can be found; but rather a combination of several conditions, which may change at fairly frequent intervals, must be taken into account when instituting a program of effective control of heating ingots for a primary mill. The knowledge of these vital factors on operating techniques very readily justify the time spent in their development and contribute to the basic economy of the operation itself.

DESCRIPTION OF BLOOMING MILL

Soaking pits.—There are six rows of two holes each of center, bottom-fired, recuperative type soaking pits. The dimensions are 12 ft-9 in. x 15 ft x 9 ft-6 in. They are oil or CO gas-fired but for the past few years have been exclusively on CO gas with a calorific value of 550 btu per 1000 cu ft. Each pit has an automatic reversal, pressure and temperature control system. Air is preheated to 1500 F, and pit temperature is approximately 2400 F.

Cranes—The pits are serviced with one 10-ton telescopic ram ingot charging crane for hot top ingots and two 7½-ton stiff leg cranes. The crane span is 81 ft-4 in. Two pit cover gantry cranes of 28-ton capacity and one ingot transfer buggy also service the pits.

Mill—The mill is an electric motor-driven 2-high 35-in. reversing blooming mill. Rolls have a 33-in. diam with a 36-in. bull-head and 12, 9, 6, and 4-in. passes.

The mill is powered by a 700-v d-c variable voltage 50/120-rpm motor which is rated at 3500 hp but will develop 9000 hp for momentary overloads. Power at 700 v is supplied by 1500-kw d-c generators driven by a 3000-hp 6900-v, 3-phase, 60-cycle a-c induction motor and coupled to a 12 ft-9 in. diam, 66,000-lb flywheel which has a 110,000-hp-sec rating at 514 rpm. Side guards and manipulator fingers are provided at the pit side mill reversing table to facilitate entry of the ingot in the aforementioned box passes and for edge working in the bull-head.

Shear—The line flow diagram, in turn, entails suitable mill runout and shear approach tables to convey the rolled sections to a steam intensified hydraulic shear capable of cutting 200 sq in. of hot steel. A two-ton scale for weighing hot slabs and billets is located immediately in back of the shear followed by a slab piler and a butt scrap collecting area. The piler is provided for handling of sheared-to-length plate mill slabs which are in turn transferred to a slab storage yard by eight 8-ton transfer buggies. Other slabs are routed by runout tables and a turntable to the strip mill slab-conditioning yard.

Two torch cutting units, two straightening tables and a runback table are also provided to handle that portion of the rolled tonnage in the form of blooms or billets which are to be consigned to the slow cooling furnace or chipping area.

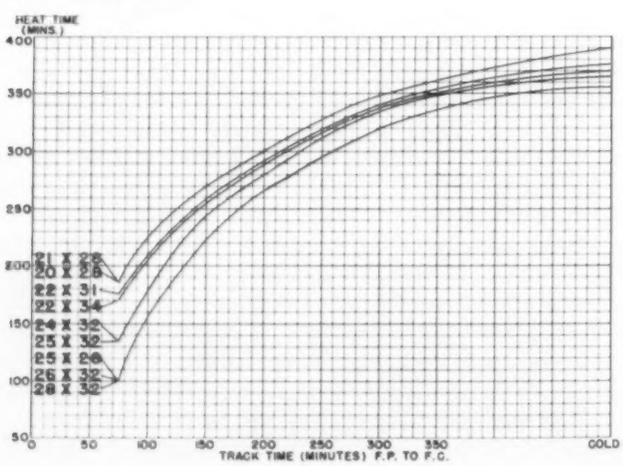
BASIC FINDINGS

Heating—In order to determine soaking pit requirements it is necessary to establish minimum and actual heating times. This also serves as an operating tool which can be used for scheduling the blooming mill according to open hearth production.

Heating results of November, 1956 were used as a base, November being conceded as an acceptable average month with 8-furnace operation in the open hearth and 20 turns per week of rolling in the blooming mill.

Heating time is defined by the Metallurgical Dept. as the time from finishing charging to the time the fuel flow is cut back to 7500 efhr. From this point until the ingots are ready to roll is considered soaking time. The total of heating time and soaking time is total pit time.

Figure 1 — From production records come this family of track time vs required heating time curves for various sized ingots. The curves are on a per-ton-charged basis, not an ingot basis.



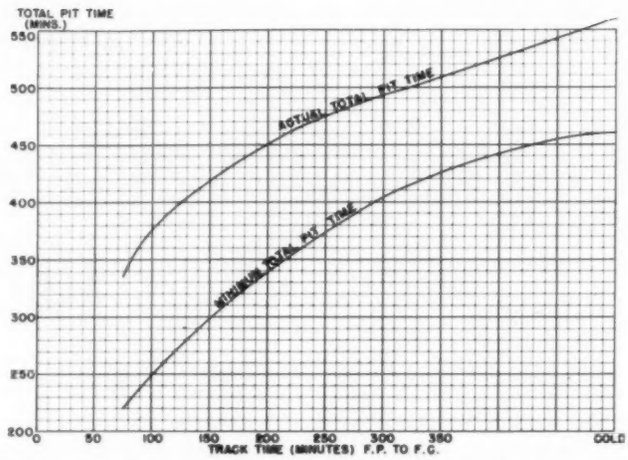


Figure 2 — On a per-ton basis the actual and minimum total pit times are a function of track time but are independent of ingot size.

The total pit time reflects all mill and pit delays. Therefore, in this analysis mechanical recordings of heating time and determined soaking time were used as a basis for all development.

Figure 1 shows the heating time for each ingot size plotted against track time. It is apparent that larger ingots heat faster than smaller ingots. This comparison is of equal tons charged, not an ingot per ingot comparison. One explanation is that an entire charge of small ingots has more surface area than a charge of large ingots and therefore lose more heat with a given track time.

Figure 2 shows the minimum and actual pit time for all ingot sizes plotted against track time. There was so slight a difference in pit time between sizes that, for practical application, all ingots have identical total pit time.

An interesting sideline to this analysis is that the blooming mill foreman and the blooming mill industrial engineer conducted separate but simultaneous field checks to substantiate all data. Then the basic data was statistically checked by calculating the standard error of estimate and the coefficient of correlation. All checks indicated that we were on safe ground for continuing with a complete evaluation.

Full pit cycle—With a minimum total pit time established, it becomes necessary to establish time for all constants and variables which determine the standard or normal total time from start-charge to start-charge. These are: charging time, heating time, soaking time, mill delays, pit delays, and drawing or rolling time.

Charging time, shown in Table I, is based on the average number of ingots charged per pit. The amount of pit coverage is limited by heat size which has been further complicated by the recent addition of a 250-ton

TABLE I
Pit Charging Times

Ingot size, in.	Average no. of ingots per pit	Time to charge ingot, min	Total charge time, min
20 x 28	14.75	0.706	10.4
22 x 31	11.96	0.741	8.9
25 x 28	10.71	0.755	8.1
22 x 34	10.44	0.747	7.8
25 x 32	10.04	0.757	7.6
28 x 32	8.58	0.816	7.0

TABLE II
Average Blooming Mill Delay Hours Per Operating Turn

Pits	Hr
Nothing hot	0.45
Charging	0.01
Fallen ingot	0.01
Cranes	
Electrical	0.01
Mechanical	0.03
Sub total	0.51
Mill	
Roll change	0.10
Bearing change	0.02
Mechanical	0.05
Electrical	0.01
Adjust, line up and check mill	0.06
Scrap caught	0.04
Ingot caught	0.01
Sub total	0.29
Tables and shear	
Mechanical	0.10
Electrical	0.03
Tieups (ingot and yard jams)	0.02
Sub total	0.15
Lunch	0.25
Department total	1.20 15 per cent of turn

TABLE III
Pit Delays

Track time range, min	Min delay per charge
50–100	82
100–150	84
150–200	67
200–250	57
250–300	36
300–350	23
Cold	31

TABLE IV
Drawing Times

Ingot size, in.	Tons per hr	Total rolling time per pit, hr
20 x 28	98.5	0.69
22 x 31	115.8	0.59
25 x 28 B.T.	110.0	0.62
22 x 34	116.3	0.59
24 x 32 B.T.	120.0	0.57
25 x 32	124.8	0.55
28 x 32	129.1	0.53
26 x 33 H.T.	123.4	0.55
21 x 28 H.T. (est.)	100.0	0.68

open hearth furnace and the conversion of another to 250 tons. Pit capacity is rated at 75 tons. However, when charging 140-ton heats only 70 tons can be charged to a pit, and with 250-ton heats only 62.5 tons can be charged to a pit without mixing ingot sizes and/or grades. The 250-ton heats were made possible by use of bifurcated spouts and the installation of light weight ladle crane trolleys.

Heating and soaking time has been determined in the preceding section.

Mill delays represent 1.2 hr or 15 per cent of each operating turn. A breakdown is shown in Table II. The greatest single delay is downtime because of steel not being ready to roll. This situation occurs when the open hearth tapping cycle does not coincide with blooming mill rolling. Pit delays, as used in this report, refer to a charge of ingots remaining in the pits longer than necessary because two or more charges are ready to roll simultaneously. This pit delay is the time lost from cutting pit temperature back to 2200 F and holding at 2200 F until shortly before it is scheduled to the mill. Table III shows this average time. Note that as track time and pit time increases, the occurrence of pit delays decreases. This seemingly peculiarity is due to a greater number of heats in the lower track time ranges than in the high track time ranges.

Drawing or rolling time depends upon the section being rolled and the ingot from which it is rolled as shown in Table IV. Since the basic intent is to provide small sections from small ingots and to provide them as uniformly as possible, the drawing time has been simplified by considering the average rolling time by ingot size as a reflection of mill practice.

For each ingot size the full pit cycle is found by adding each of the above constants and variables. Two examples are shown in Figure 3.

Considerable added benefits are manifested by proper scheduling of the pit drawing cycles in keeping with a minimum of lost motion and ingot temperature loss. Although the current practice of signalling for the next ingot is in the hands of the rolling crew, the added advantages of having the heating group responsible for meeting this requirement with a minimum of mill delay is being investigated.

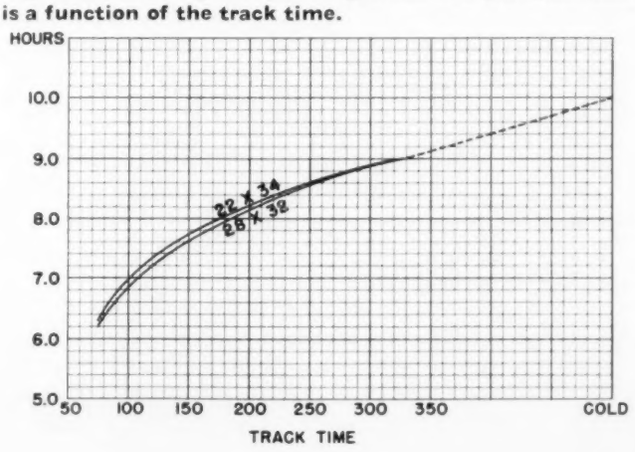
Pit turnover—The full pit cycle has been developed. Therefore, the next step in determining pit requirements is to calculate the frequency of pit usage or the rate of turnover.

Average turnover is dependent upon pit availability, pit empty time, track time, mill delays and product mix.

Pit availability is based on an estimated downtime for repair work and rebuild of 2.18 per cent of all pit-hours. This figure is based on 400 pit-hr of lining, 800 pit-hr of rebuild, and 1000 pit-hr of repair for all 12 pits per year. Our recent change to a hard bottom pit practice has attributed to the good pit availability showing as well as making direct manpower and coke cost savings. Additional savings through cold spraying of side walls and ramming the pit covers is being strived for experimentally. Both experiments show encouraging results.

Pit empty time reflects the affect of bunched heats from the open hearth and the absence of a cold steel

Figure 3 — For a given sized ingot the full pit cycle time is a function of the track time.



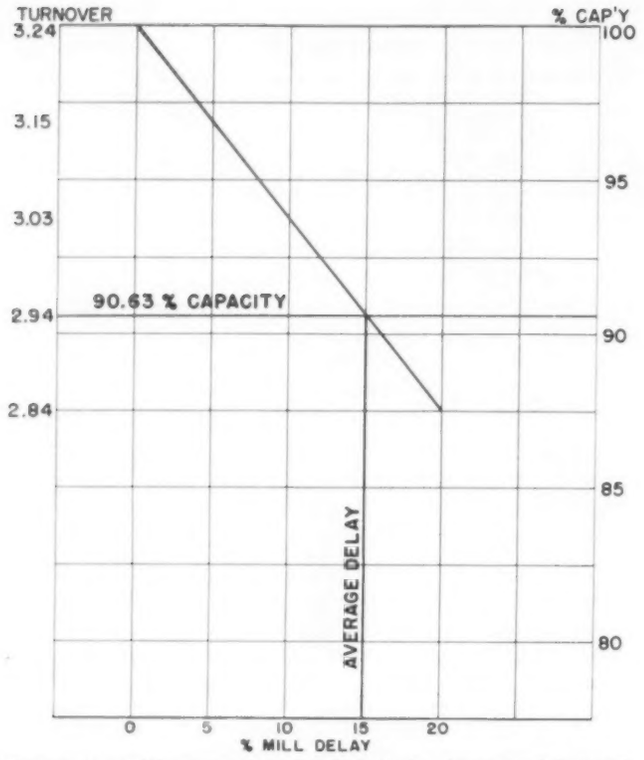


Figure 4 — This curve for the 22 x 31-in. ingots with track times in the range 100 to 150 min shows the effect of mill delays on pit turnover.

bank. Increased open hearth production will fill in gaps caused by the absence of a cold steel bank. However, if additional pits are added, there will be a proportional increase in empty pit time. It is concluded, therefore, that this empty pit time condition will neither improve nor become worse. The soaking pits are empty 9.38 per cent of the total available hours.

Track time, as it affects pit turnover, is shown in Figure 4. With decreasing track time the full pit cycle is less. This however is not a straight line relationship. For this reason average track time cannot be used to develop soaking pit requirements. The cycle time for each track time range must be weighted with the per cent of all ingots falling within that range. Table V shows this per cent distribution.

A graphic presentation of this turnover relationship amplifies what is common knowledge in such a way that future action becomes based upon tangible figures instead of rule of thumb technique. At present, the location for a new stripper crane is very seriously being considered. The advantages of a location adjacent to the soaking pits are strong.

Mill delays as related to turnover is expressed graphically in Figure 5.

TABLE V
Distribution of Ingots by Track Time

Track time range, min	Per cent of ingots
50–100	23.56
100–150	27.80
150–200	17.29
200–250	8.64
250–300	6.27
300–350	2.88
Cold	13.56
	100.00

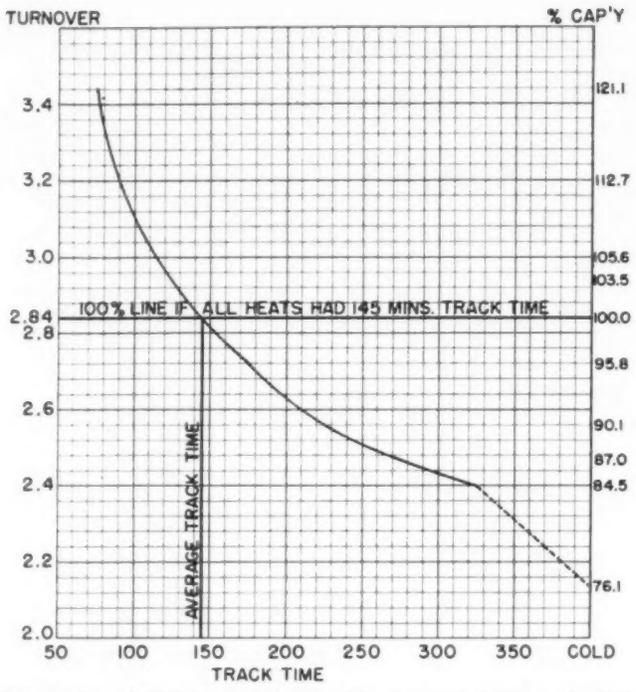


Figure 5 — Influence of track time on capacity of pits under actual conditions.

Product mix is the crux of accurate determination of pit requirements. Although the general practice is to provide small sections from small ingots and large sections from large ingots, the section-ingot relationship cannot be specifically tied down except for a few examples. These are: $4\frac{1}{2} \times 4\frac{1}{2}$ in. and 6×6 in. are always provided from the 21×21 in. hot top, and a 8×30 in. for the plate mill is only possible with the 22×34-in. ingot. A minimum 4-in. reduction on edge is maintained except for the 4×28-in. plate mill slab from a 22×31-in. ingot. The extreme overlapping of possible provision can be seen by examining Table VI.

At present a Yield Committee, comprised of top operating and metallurgical supervision, is conducting comprehensive analyses of all conditions which affect yield. One of the results will be the determining of a new mold size to accompany the growing demand for 30-in. slabs. It is hoped that this new mold will replace the present 28×32 in. The design considered is a 27×35-in. corrugated mold which will give an ingot weight of approximately 14,500 lb when poured to a height of 70 in.

For prediction of product mix the trend towards larger ingots and elimination of billet trade is weighted with past performance. Some ingot sizes will be eliminated, some used more extensively, and others added. A prediction for the immediate future is shown in Table VII. This product mix is used in the final development of soaking pit requirements.

Analysis of present practices—Basic data has been developed which can be used to determine soaking pit requirements. However, before stepping into that phase, it is advisable to analyze some of the factors which have been singled out for improvement and which cause long full pit cycles and low pit turnover.

Charging time and pit capacity utilization are adversely affected by sticker ingots. This condition is being approached experimentally by the open hearth under direction of the Yield Committee.

TABLE VI
Sections Provided by Ingot Size

Ingot size, in.	Strip mill		Plate mill	
	Minimum, in.	Maximum, in.	Minimum, in.	Maximum, in.
20 x 28	3¼ x 7½	4¼ x 24	3 x 19	8 x 25
22 x 31	3½ x 11	4¼ x 27	4 x 22	4 x 28 or 8 x 25
22 x 34	3½ x 16	4¼ x 27	4 x 22	8 x 30
24 x 32 B.T.	3½ x 18¾	4¼ x 27	4 x 22	8 x 28
25 x 28 B.T.	3½ x 12	4¼ x 24	4 x 22	8 x 25
25 x 28	3½ x 14½	4¼ x 24	4 x 22	8 x 25
25 x 32	3½ x 17½	4¼ x 27	4 x 22	8 x 28
28 x 32	3½ x 17½	4¼ x 27	4 x 22	8 x 28
21 x 28 H.T.	3¼ x 12	4¼ x 22	4 x 22	8 x 22
26 x 33 H.T.	3¼ x 18	4¼ x 27	4 x 22	8 x 28

TABLE VII
Ingot Mix Prediction for 800,000 Ingot Tons Per Year

	No. of ingots	Per cent of total number	Tons per ingot	Ingot tons	Per cent of ingot tons
Hot tops	8,507	6.5	6.0	51,039	6.4
18 x 28	...	...	...	...	...
20 x 28	28,790	22.0	4.8	138,197	17.3
25 x 28	...	...	...	...	...
22 x 31	20,939	16.0	5.6	117,258	14.7
25 x 32	18,322	14.0	6.9	126,419	15.8
24 x 32 B.T.	10,470	8.0	6.4	67,005	8.4
25 x 28 B.T.	9,161	7.0	6.3	57,713	7.2
28 x 32	17,013	13.0	7.7	131,000	16.4
22 x 34	17,678	13.5	6.3	111,369	13.9
	130,880	100.0		800,000	100.0

Long track time can easily be caused by insufficient ingot buggies. The effect of track time has been presented in both the heating and pit turnover sections. In determining the number of ingot buggies needed it is necessary to first consider the open hearth requirements. Basically we must allow sufficient buggies so that no mold will have to be used more often than every ten hours and that an optimum mold inventory may be maintained. This can be done by having one string of buggies for each furnace. Each of these strings needs an average of 12 buggies. To insure against the possibility of having to use the same molds again a string should be held empty for emergency. This string needs 14 buggies held under the stripper crane for the placement of stripped molds. With our availability picture it was recommended to have 174 ingot buggies.

The desirability of holding ingots under cover, especially for some killed heats, was recognized and has contributed to the possibility of locating a new stripping crane adjacent to the blooming mill.

Under study by the Yield Committee is the possibility of using theoretical ingot weight. This will contribute towards decreasing track time by eliminating the weighing operation.

"Nothing hot delays" are an undesirable result of bunched heats. However, they do allow time for the adaption of preventive maintenance practices which in turn improve the mill delay picture. To keep the "nothing hot delays" to an acceptable minimum, an attempt is made to intersperse slow rolling with fast.

Operating guide—An important outgrowth of an analysis of this nature is giving the operating department a tool which can be used for scheduling or predicting work load. A general guide for foremen and heaters for charging, predicting roll order, and informing the open hearth of delivery times is:

Charging:

1. If two or more heats are delivered or can be delivered simultaneously, charge the hottest heat (most recent tap).
2. If two heats have identical tap times (± 10 min), charge the smaller ingot first.

Predicting roll order:

1. Minimum total time in pits is track time (tap to finish-charge) plus two hr. Cold steel = 7 to 8 hr.
2. After fuel is cutback to 7500 cfhr, allow the following soaking time: (unless visual inspection shows less).

Size, in.	*Time, min*
20 × 28	30
22 × 31	40
22 × 34	50
24 × 32	60
25 × 32	60
25 × 28	60
28 × 32	75

SUMMARY

The full pit cycle time for each ingot size has been established within several track time ranges. Net pit availability was calculated to be 97.82 per cent and actual pit availability was found to be 9.38 per cent less than net due to fluctuations of the steel-producing, furnace-tapping schedules.

Average charge weight per pit, with eight-furnace operation, (two making 250-ton heats and the balance 140-ton heats) will be 67.63 tons. An average full pit cycle time, after correlating the product mix with the individual cycle time, is 7.84 hr. On the basis of these determined facts, soaking pit capacity is 801,620 ingot tons per year. Above 801,620 ingot tons per year, the soaking pit capacity is deemed inadequate. An expansion to 930,000 ingot tons per yr must be accompanied by one or more rows of soaking pits.

Discussion

PRESENTED BY

H. C. HENSCHEN, Special Engineer, Fuel Dept., Bethlehem Steel Co., Sparrows Point, Md.

J. LEO HAGAN, Fuel Engineer, Utilities, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

M. B. DEYSHER, Assistant Superintendent, Shape Mills & Soaking Pits, Saucon Div., Bethlehem Steel Co., Bethlehem, Pa.

C. W. DUNN, Superintendent of Utilities, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

GEORGE J. MENG, Industrial Engineer, Alan Wood Steel Co., Conshohocken, Pa.

C. E. Pritchard, General Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

H. C. Henschen: There are many easier and simpler ways of determining the number of pits required to do a given job, but this method is the only one which can

be considered accurate. I should like to know how many pit heats are represented by Figure 1.

At Sparrows Point we have from time to time made similar studies. Soaking pit requirements for the recent 2,000,000-ton per yr expansion were determined by the "pit cycle time" method Mr. Meng described. We had one complication, however, in that the new slabbing mill was to roll only 13 turns per week. Our problem was simplified, on the other hand, by having previously correlated data on pit performance.

It was interesting to hear that at Alan Wood different ingot sizes with the same track time take different times to heat. Some time ago we noticed the same phenomenon. Our common ingots vary from 1130 sq in. of exposed surface per ton to 1450 sq in. of exposed surface per ton or a spread of 29 per cent. By comparison the Alan Wood ingots vary from 1000 sq in. per ton to 1200 sq. in. per ton or 20 per cent. In making comparisons of the performance of different pits we have tried to correct for the different heat losses encountered when ingot surface areas are so widespread.

At first glance it would seem that Alan Wood requires much more pit area to heat 801,600 tons of ingots per year than would many other plants. Mr. Meng has described his operation in such detail that it is easy to see where the difference lies:

1. The Alan Wood pits are not charged very heavy. Hearth coverage varies from 28 to 30 per cent as compared with 40 to 45 per cent for our pits. It is acknowledged that the burner in the center of the bottom-fired pit prohibits charging an ingot there.

2. Pit cycle time is somewhat longer than ours. For example, when considering the hot steel only, an average cycle time at Alan Wood is 7.4 hr vs 6.7 hr at Sparrows Point. There are indications that the Alan Wood pits are not fired very hard. I would like to ask what the maximum firing rate is.

As pointed out by Mr. Meng, rolling time is a part of pit cycle time. Consequently rolling rate alone could account for a major difference between his pit cycle time and the cycle time of pits serving a 40 × 80-in. slabbing mill.

I should like to make it clear that the above comparisons were made only to show wherein a "short cut" analysis of soaking pit requirements would be totally inaccurate. An example would be a tons per square foot per month basis.

J. Leo Hagan: Considering Figure 2, the actual pit time vs minimum pit time, you show about a three-hr loss of pit availability per heat.

In Table II your operating mill delays are less than ½ (0.45) hr per operating turn, charged against waiting on hot steel from the soaking pits. If this be the case, will you not need a higher mill capacity? With an increase in mill capacity you should be able to decrease the present actual total pit time per heat and it appears that you could then get a greater output from your present soaking pits.

A high capital outlay is needed for constructing new soaking pits. Have you considered a furnace of a type that could be used for holding ingots, after stripping, at a track temperature until pit space is available for charging?

M. B. Deysher: One of the most costly delays of any blooming mill operation is recognized as "nothing hot" downtime due to insufficient heating capacity. In this case 37.5 per cent of the bloomer delay time is caused by "nothing hot," and methods should be considered to reduce this lost time. Your track time study shows that with a proposed increase in open hearth production, congestion at the soaking pits will also increase; and additional pit hearth area is necessary to handle the higher tonnage.

It was mentioned that hard bottoms are used rather than coke breeze. Can you substantiate savings by using a hard bottom, and does this practice affect heating or yields in any way?

C. W. Dunn: I had difficulty understanding why you did not take the ingot size into consideration in the plot of total pit time vs track time. In Figure 1 you showed that considerable difference existed, which correlates with our findings. However, you then disregarded this in Figure 2, total pit time vs track time.

Another point, which needs study, is the bunching of heats in the open hearth and its effect on track time and pit availability. Our experience indicates this to be an important practical factor in designing rated capacity.

George J. Meng: This study represents data on approximately 5500 heats. Our maximum firing rate is 13,750,000 btu per hr. This is 25,000 cfhr of CO gas with a calorific value of approximately 550 btu per cu ft.

The difference between actual pit time and minimum pit time is between 1½ and 2 hr. The great difference between our actual time and our minimum time is not only mill and pit delays but also the pit time lost by having two or more pits ready to roll simultaneously.

With a higher capacity mill, we would get some decrease in actual total pit time and a greater output from our present soaking pits.

As for holding furnaces for ingots, we have considered a pre-heat furnace for our plate mill rotary furnace.

C. E. Pritchard: We have considered the possibility, depending upon the type of expansion and location of the stripper, but it has not been formalized; and it does not look as though we would consider it as part of any immediate program.

George J. Meng: In an effort to minimize "nothing hot" delays we try to intersperse fast rolling with slow rolling. We take advantage of these delays to conduct a preventive maintenance program on the mill.

Our experience with hard bottoms has to date been satisfactory. The blooming mill is saving about $9000 per yr in coke breeze cost and $27,500 in labor. The savings in coal to our power house is running about $23,500 per yr. Heating time gained by elimination of "green" bottoms accounts for about 800 net tons. Against these gains we have the additional expense of about $2600 for periodically cleaning out bottoms.

No credence is given to ingot size in the final development of total pit time because in our particular pit practice all gains made in heating (time from finish-charge to fuel-cutoff to 7500 cfhr) of the larger size ingots are offset with a proportionately longer soaking time.

We did not make a special study of the tapping schedule as such. By using track-time occurrences based on 5500 heats, we believe the variance in tapping cycles is automatically taken into consideration. ▲

Improved Lubrication in cold strip rolling

by J. C. Whetzel, Jr., and Sayre Rodman, Partners
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. . . . either an increased pass reduction for the same rolling load or a decreased rolling load for the same pass reduction can be realized by improved lubrication of the bite contact surfaces between strip and rolls . . . . preliminary laboratory results indicate that, for a given amount of lubricant, increasing its viscosity up to certain value reduces rolling loads . . . . also water soluble chemicals and mixtures were found to be the best lubricants . . . .

THIS paper concerns the effects of lubrication on friction in the cold rolling of strip metals. The data presented summarizes the results, to date, of a research program using a small rolling mill. For the most part, thin strip steel was the metal used, although there are a few examples of stainless steel and copper. In part of this work a broad range of mineral oils, fats, and synthetic organic chemicals were screened for their performance as rolling lubricants. The fats were selected for intensive research on their behavior under varying conditions of rolling and different methods of use. This laboratory work has suggested possible improvements in commercial practice.

FRICTION IN COLD ROLLING

In the cold rolling of strip metals, friction between rolls and strip is responsible for some of the most significant forces. As strip is rolled or reduced, it elongates, and changes speed relative to roll speed and must inevitably slide against the roll surfaces. The resultant friction produces forces which try to retain the strip in the roll bite. This action builds up pressures which increase the required rolling loads and torques. Even though a complete solution has never been presented, present theoretical analyses of the mechanics of the process are very complex.[1]* However, a comparatively simple set of equations were developed by Stone and Greenberger, who assumed average values for strip thickness, yield strength, coefficient of friction and other quantities everywhere in the roll bite. Comparable calculations made with more detailed equations have convinced the authors of this paper of the accuracy and general utility of these simpler expressions for most practical conditions. For details, the reader is referred to their original article and subsequent discussions.[2]

To illustrate some typical effects of friction a set of solutions of the Stone and Greenberger equations are shown graphically in Figure I. Calculations assume 20-in. diam steel work rolls, taking 25 per cent reduction in strip metal with an average yield strength of 95,000 psi. That is, if the delivered gage as plotted on the graph is 0.015 in., the original gage before reduction was 0.020 in. Each curve, for a specific coefficient of friction, slopes down with decreasing strip thickness, reflecting less metal-working required, then rises sharply as the load multiplying effects of friction and roll-flattening take hold. Although Figure I applies only to the conditions stated, solutions for other dimensions and yield strengths will have a roughly similar appearance.

Lubricants applied to strip and roll surfaces control friction, the degree of necessary control being dictated by the particular rolling job. It is evident from this graph that friction exerts a much greater effect on rolling load as the rolled strip becomes thinner. Therefore, greater efficiency of lubrication is required in this range. For example, if 0.030-in. gage is rolled, a decrease in coefficient of friction from 0.03 to 0.02 yields a drop in rolling load from 53,000 to 49,000 lb per in. of strip width,

* Numbers refer to Bibliography at end of article.

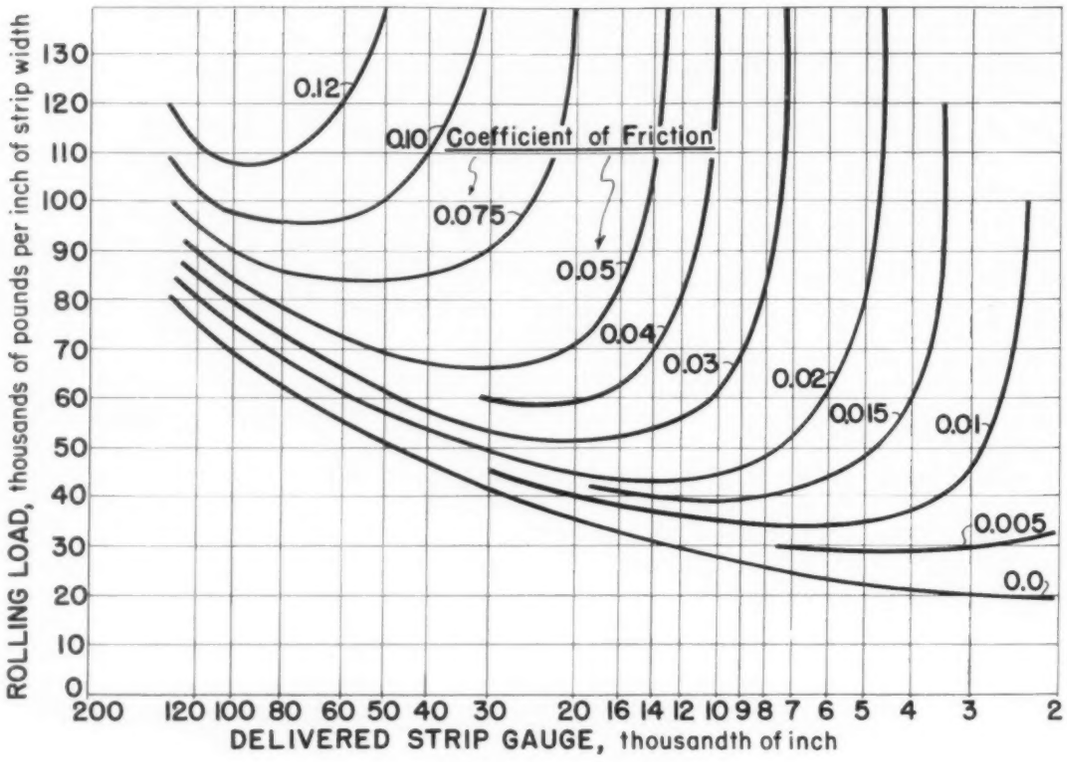


Figure 1 — These curves of required rolling pressure vs delivered strip gage for 25 per cent strip reduction show the effect of coefficient of friction between strip and rolls. These were calculated from a set of equations developed by Stone and Greenberger.[2]

a decrease of 7.5 per cent. However, if 0.010-in. gage is rolled, the theoretical load with a 0.03 coefficient is 62,000 lb per in. and drops, to 45,000 lb per in. at 0.02 coefficient, a decrease of 27 per cent. Also, in the case described, it would be almost impossible to roll 0.010-in. gage with a coefficient equal to 0.04 since the required load would now be in excess of 130,000 lb per in. As the rolled gage decreases still further, these effects dictate very careful choice of lubricant and conditions. On the other hand, at the extreme left end of the graph, in the range of 0.080-in. delivered gage, a rather large change in coefficient, from 0.03 to 0.075, changes the required load from 73,000 to only 86,000 lb per in.

The range of coefficients of friction produced by lubricants, as determined with highly experimental lubricants, will seldom be above 0.10 and will be below 0.01 only in rare cases. The best coefficients in commercial practice, in the range 0.02 to 0.04, will usually be found on high-speed mills using fatty lubricants. The most common range is probably 0.04 to 0.08.

On most mills there is a minimum level below which friction must not be reduced by over-lubrication or other means. If friction drops too low, the grip required to keep the strip moving through the roll bite will be lost. This forward force can be provided on some mills by a large excess of front-over-back tension in the strip. In most cases, though, rolling grip must be maintained by friction in the roll bite, between rolls and strip. The exact amount of friction required is hard to predict. However, theoretical calculations and some laboratory data point to the following approximation. For any specific case, as the coefficient of friction is reduced (rolling load drops accordingly), the minimum usable friction level is not reached until the actual load is close to the load as calculated by Stone's method for a coefficient of friction approaching zero. This minimum value of coefficient of friction is by no means a constant, being much lower for thin hard strip than for thick, soft metal. For any specific job the minimum lies low enough so that there would be no reason, as far as effective decrease of rolling load is concerned, for approaching it.

LABORATORY ROLLING MILL EQUIPMENT

For investigation of rolling lubricants, a small rolling mill was considered the best available tool. Use has proved this mill to be a sensitive research method, yielding results which closely parallel observed industrial mill performance. Employed was a 2-high roller bearing mill with 4-in. diam x 6-in. face rolls driven through a pinion stand by a four-speed a-c motor. By changing drive sprockets the available peripheral speed range of the rolls was 100 to 1000 fpm. Other accessory equipment included a constant torque take-up reel for rolled strip and accurate load measuring cells under each mill screwdown. These cells were beams or columns with attached strain gages, designed to indicate any load from a few hundred through about 30,000 lb. Another device was a marker which could place spots on moving strip at precisely timed intervals. This marker could also be timed to roll revolutions. Later measurements of the spot spacings permitted calculation of either strip speed or speed relative to roll surface revolutions. Also provided were various lubrication application systems including a thermostatically controlled recirculating system which could flood the rolls and strip with a large volume of either emulsion type lubricants or water, at any desired temperature. Entry guides, pay-off reels and other equipment were designed and built as required.

GENERAL LUBRICATION EFFECTS

The earlier stages of the investigation involved the screening of a broad range of potential lubricants for

their effect on friction. One or more runs were made on at least 400 different materials or mixtures. The choice was not limited to materials normally considered lubricants. Many pure organic compounds were tested to seek out completely new and more effective materials from a polarity or chemical activity point of view. Any material which could be applied in liquid form without injury to the mill was considered eligible for test.

A short cut procedure was used for much of this work since the intent was to investigate new trends and not to examine exhaustively any particular lubricant or combination. Constant rolling speed and load were selected such that changes of friction in the anticipated range would give major changes in the rolled strip thickness. During rolling, the entrance to the mill was flooded with the desired lubricant. The same strip being used throughout, the degree of reduction obtained proved to be a sensitive measure of lubricant performance. This procedure proved to be rapid, and cleaning the rolls between runs was often more time consuming than any other part of the work.

A few results typically obtained with well known materials are given in Table I. The lubricant indicated, all liquids at the temperature employed (100F), were applied as described; both the rolls and strip were flooded. Rolling speed was constant at 300 fpm. Results are given as per cent reduction, in one pass, with constant rolling load for each type of strip metal, as shown. For reference, calculated coefficients of friction for steel range from 0.076 (70 SUS viscosity mineral oil) to 0.022 (water soluble compound No. 3). Because the particular yield strength was not known for the other metals, no calculations were made.

Certain general conclusions applicable to rolling thin steel strip stand out from the work to date. Within the broad range of materials tested, performance trends appeared to depend on the physical properties of the lubricant composition and the chemical nature of its major ingredients. With only a few exceptions behavior was unaffected by small amounts of additives chosen for chemical activity. This is in marked contrast to lubrication of bearings and also lubrication of some nonferrous strip rolling.

For thin strip rolling the hydrocarbons, including petroleum oils, showed little promise. Synthetic hydrocarbons were even worse. Particularly with steel strip, additions of so-called lubricity-improving agents showed no marked effect until the additive level approached major proportions. For example, mixtures of fatty acids or fats with petroleum oils showed effects roughly proportional to the relative fat and petroleum oil ratio. Among similar petroleum oils, progressive increases in viscosity showed progressive improvement in rolling lubrication as the table shows. However, in the higher viscosity ranges, well above that shown in the table, strip irregularities appeared, variously called weaving or curled edges. With extremely viscous hydrocarbons the mill often delivered a stream of chips instead of strip in one piece. A minor amount of work was done using emulsified or soluble petroleum oil mixtures with water. There was too little of this work to afford broad comment. But, generally, these emulsion or suspension mixtures suffered from the basic weaknesses of the parent oils.

New families of outstanding lubricants were found among the general class of "oily" liquid chemicals which are soluble in water. It appears, in the experience of the authors, that chemical activity or polarity, which effects maximum rolling lubricating ability, also confers water solubility although, of course, the converse is not necessarily true. These materials also showed that progressive viscosity increases in the same family gave increasingly better lubrication. At reasonable viscosity levels these water soluble chemicals and mixtures showed much the best lubricating ability of any materials yet tried (refer to Table I for typical range). Because they are ineffective in dilute water solution, their potential use is restricted to slow-speed mills where large volumes of cooling water are not required. They have potential use in slow speed rolling of hard metals, or possibly where advantage could be taken of their solubility for ease of cleaning. At present they are experimental and still in development.

Fatty oils, as is well known, perform very well as thin strip lubricants. It was found that all natural fats, from whatever source, behaved almost identically. Variations in free fatty acid content, from 0.25 per cent through 12 to 15 per cent had no measurable effect. Above 15 to 20 per cent, performance declined perceptibly to that of the fatty acids themselves, which was measurably worse. It was found among fats also that good performance was dependent on viscosity more than on any other single factor. A large amount of work was devoted to fats applied to the mill in emulsion or suspension form because of the large amount of rolling done using fats in this manner. Important trends here concerned the proper balance of emulsifier or other aspects of oil dispersion to permit the best rolling. The beneficial influence of increased fatty oil viscosity was also evident, even in water suspension.

TABLE I
Effect of Lubricant on Cold Reduction

Strip material / Lubricants	Per cent reductions for given rolling loads		
	Steel 0.0063 x 0.250 in. SAE 1010 cold rolled Load: 3800 lb	Stainless steel 0.0052 x 0.250 in. Type 302 annealed Load: 6000 lb	Copper 0.0055 x 0.250 in. annealed Load: 1600 lb
Fatty oils			
1. Typical animal fat	32.5	20.0	31.0
2. More viscous fat	39.0	25.0	34.5
3. Stearic acid	32.5	18.0	27.5
4. Oleic acid	30.0	...	...
5. Palm oil	32.5	...	...
6. Acid less tallow oil (0.25 per cent free acid)	32.5	...	...
Petroleum oils			
1. 70 SUS, 100 F	16.0	12.5	19.0
2. 600 SUS, 100 F	24.0	15.0	22.5
3. 600 SUS plus 5 per cent stearic acid	24.0	15.0	23.5
Experimental water soluble types			
No. 1	28.0	16.0	24.5
No. 2	40.0	26.0	36.5
No. 3	59.0	38.5	59.0

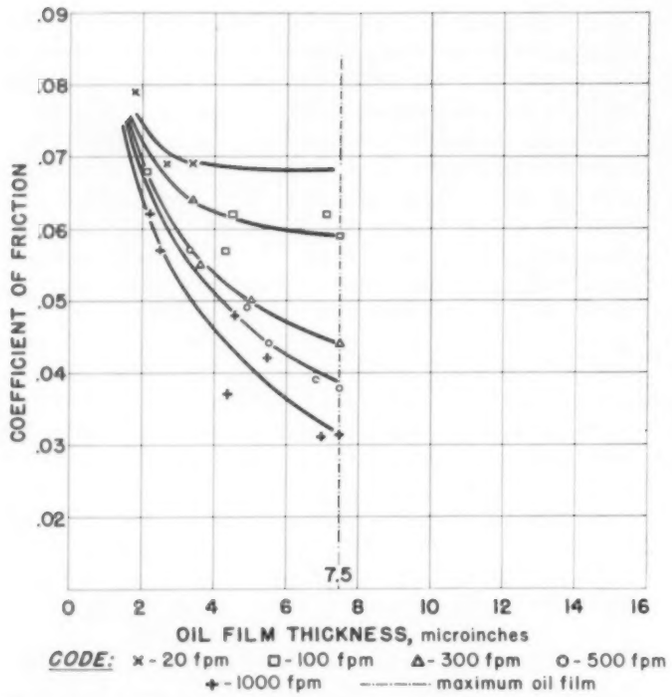


Figure 2 — These curves show the relationship between coefficient of friction and oil film thickness at various rolling speeds. On a natural animal fat pre-coated steel strip the oil film thickness was measured and the coefficient of friction was calculated by the Stone and Greenberger method.[2]

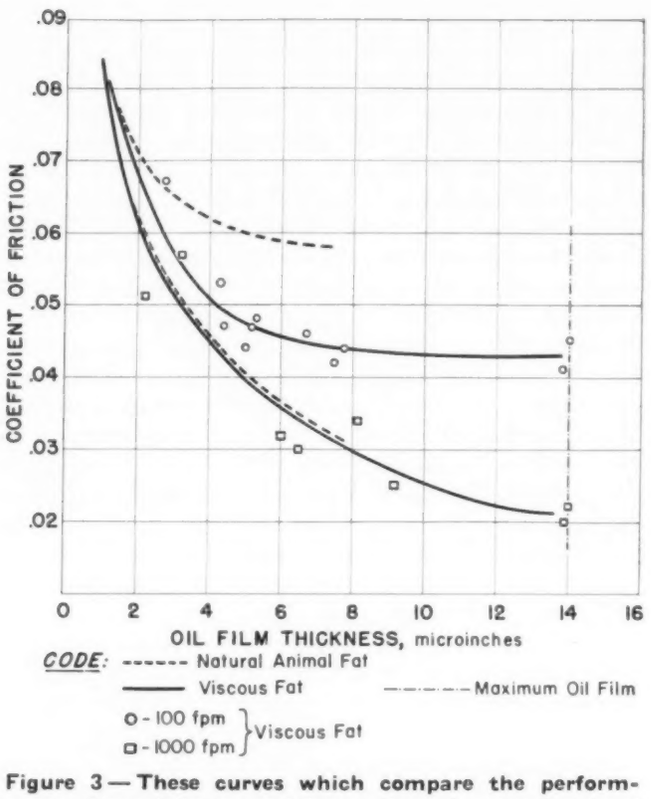


Figure 3 — These curves which compare the performances of specially treated fatty oils and natural animal fat were compiled in the same way as the curves of Figure 2.

BEHAVIOR OF FATTY OIL LUBRICANTS' OIL FILM

The general field of fatty oils, in natural and modified forms, was selected for special investigation in the rolling of strip steel. While these oils do not approach the spectacular decrease in friction possible with water-soluble synthetic compounds, they are presently the most useful in the field of thin strip rolling. The work done to date is far from complete, being limited by time and available equipment. It would have been desirable to extend the scope of these investigations by employing other metals, larger rolls, higher speeds, and more variations in strip gage and finish. However, the work to be described is indicative of the extent of research warranted for any one oil type.

The most interesting information on fatty oil behavior was obtained by measuring the influence of oil quantity on rolling in addition to the usual rolling data. Oil films on the surface of rolled strip were measured for a variety of conditions with both a representative natural fatty oil and with a chemically modified fat of higher viscosity. To obtain measurements of oil films the following procedure was used. Strip to be rolled was pre-coated with uniform amounts of fatty oil lubricant either by deposition from solvent solution or by various types of air-powered spray apparatus. These films varied from barely oily, ineffective layers to gross excesses. For roll and strip temperature control the mill itself was flooded with re-circulating hot water (140 F). The water contained adequate emulsifier to keep suspended any tramp oil without disturbing the established films on the strip. During rolling, excess water was blown off the strip on the delivery side of the mill prior to coiling on a clean take-up reel. The strip was rolled to a specific gage for comparative purposes, noting rolling load. A measured area of the rolled strip was then exhaustively degreased in freshly distilled hexane, and the oil was weighed after complete evaporation of hexane in a tared container. This oil quantity is expressed as the average thickness of the film, in microinches, over the measured area. Coefficients of friction corresponding to the various films were calculated from the rolling data by the Stone and Greenberger method.

For the majority of this work the strip used was cold rolled and degreased steel (SAE 1010), 91,000-psi yield strength, 0.0063 in. thick, slit to 0.250 in. width. The thickness was selected because it permits investigation in the interesting range of coefficients of friction from 0.10 to 0.01. Within this range rolling of the chosen strip is neither too difficult nor so easy that friction has little effect on load. The width, 40 times the thickness, appeared adequate to minimize edge effects while permitting ease of handling at high speeds.

Figure 2 shows typical results of this work using a natural animal fat pre-coated on the strip. Plotted are the oil films, in microinches, on the rolled strip and the coefficients of friction calculated when the strip was rolled. Data for various rolling speeds are presented. Runs were made at both 19 and 33 per cent reduction and were found to agree within the limits of apparent experimental error. The vertical dotted line at the right of the curves represents the maximum oil film which would pass through the rolls, regardless of the amount on the strip entering. This quantity was hard to measure because large excesses of oil at the entrance to the roll bite produced a bead of oil on the edges of the rolled strip, instead of washing or blowing off as was the case with small oil excesses. Another series of tests with wider

strip and special edge wiping techniques gave the same film thickness, within 10 per cent error, over the whole speed range when the feed strip was heavily pre-oiled. This average film (7.5 microinches) is therefore presented as the dotted limit in Figure 2. It is noteworthy that the maximum oil film accepted by the roll bite did not seem to be dependent on rolling speed as might be expected. It is interesting further that samples of cold rolled strip (0.0103 gage), rolled at about 4000 fpm on a 5-stand tandem tin mill with a similar lubricant had oil films of 7 to 9 microinches.

As expected, the coefficient of friction is high for very thin oil films, dropping as the oil amount increases. However, particularly for the lower speeds, there is a point on the curves beyond which more oil does little or nothing to the friction, out to the maximum film possible. As the speed is increased, this point moves to a region of thicker films and lower friction. At the higher speeds either the curve has become straighter, or perhaps this point has moved beyond the maximum oil film line.

The speed effects shown in Figure 2 are of interest. Though the points given are perhaps inadequate to establish the matter, it is the authors' belief that for thin oil films, friction varies little with speed. The scatter of points in Figure 2 arises both from problems of measuring such thin films variation in yield strength of the slit steel strip, and also from day-to-day changes in the exact condition of the roll surfaces. However, using one reel of strip pre-coated to yield about 1 to 2 microinch-films after rolling, a series of consecutive runs at varying speeds were in almost exact agreement as to friction. At the other end of the graph, note the speed dependence of friction as any oil film thickness nears the maximum.

The next part of this investigation involved repeating these measurements using specially treated fatty oils as the lubricant. These oils are animal fatty oils modified chemically to increase their viscosity various amounts above their natural state level. These oils, it was previously noted, gave inherently better lubrication in earlier screening work. Figure 3 is a graph similar to Figure 2 with performance of both the natural and modified fats shown. For clarity of comparison, performances at only two rolling speeds are superimposed, because intermediate speeds show similar differences. Two changes in behavior can be observed. With the more viscous modified oils curve-flattening occurred at lower friction levels, and the maximum oil film passing through the roll bite has increased to about 14 microinches. In the less thick oil film range the two oils perform in a similar manner. However, at low speeds, for a range of oil film thickness greater than the inflection point, the more viscous fat gave lower coefficients of friction. At high speeds where curve flattening cannot be reached, the more viscous fat gave lower coefficients because of its ability to sustain greater film thickness.

Viscosities of nearly all natural fats, including animal fats such as used in Figure 3 are very similar. Modified fats with viscosities ranging up to fifty or more times normal have been investigated. The benefits in terms of decreased friction were found to be roughly proportional to the logarithm of the viscosity increase. The higher members of this series are physically hard to handle. However, the modified fat used in Figure 3 has a viscosity only four times normal, and, at this level there is no material difference in ease of handling but, as demonstrated, a significant change in lubricating properties.

Figures 2 and 3 and the procedures described deal only with the relationship of oil films on rolled strip and coefficients of friction obtained when these strips were rolled. The question is raised, therefore, about the interrelation of oil on the strip entering, oil films in the roll bite, and the oil films on the strip leaving the mill. Some of the oil on the strip entering, at least if the film is very thick, will not enter the roll bite. However, it seems probable that all of the oil which is trapped by the roll and strip surfaces coming into positive contact will go through the roll bite. As it emerges, the oil film then divides, in some unknown ratio between roll and strip surfaces.

An experiment was performed to demonstrate this division of oil between the two surfaces. Runs were made on the mill at constant rolling load using strip with well defined, long sections alternately cleaned (degreased) and oil-coated. Because the coefficient of friction is high for the clean or bare steel, little strip reduction was obtained in those areas. When an oily section entered the rolls, some (intermediate) reduction ensued for precisely one roll revolution. Since the rolls now were oil-coated, the next revolution gave almost the expected reduction. With the third and subsequent revolutions constant, good reductions followed showing the establishment of a constant oil film revolving with the rolls. With the transition back to bare strip, an even more extended "staircase" was found as the oil film on the rolls was divided again and again by transfer to the oil-free strip.

The ratio in which the oil film divides between strip and rolls surfaces is still unknown. The assumption is made that this ratio, if unknown, is at least reproducible for a given film thickness, other factors such as oil type and metal surface being equal. If this is true, then the oil film on the rolled strip is a good relative measure of oil films in the roll bite, and it is reasonable to present coefficient of friction as a function of oil films on rolled strip as in Figures 2 and 3.

Some actual measurements were made of the relation between oil on the strip entering the mill and oil appearing on the rolled strip. With due allowance for the elongation of the strip, films of the natural fat, up to about 4 to 5 microinches on the strip entering, passed intact through the rolls. Above this amount, increasing proportions of the oil on entering strip were rejected at the entrance to the roll bite. To obtain six microinches on strip reduced 19 per cent should have required 7.4 microinches on the strip entering, but did in fact require about 14 microinches, an excess of about 85 to 90 per cent. For the more viscous fat, about seven microinches was the maximum which would enter and pass through completely. To obtain ten microinches on the rolled strip using the more viscous fat would have required, theoretically, 12.5 microinches entering but actually required about 20, an excess of 60 per cent. A 10-microinch film could not have been obtained with the natural fat in any manner. The above figures are averaged for the various speeds at which the mill was run. While there is some tendency for more oil to pass through the rolls at higher speeds, the effect of speed, in this respect, as previously noted, was much less then expected.

A complete theoretical analysis of the means by which oil enters the roll bite is impossible at this date. However, a few factors can be discussed. The moving roll and strip surfaces can exert an important pumping effect on the oil through simple viscous drag. The exact shape of the curves along which the roll and strip surfaces approach the roll bite is unknown. However, analysis of the hydraulic forces for simple but representative shapes, such as a circle tangent to a plane, or planes approaching each other at a very low angle, shows that if surfaces move at speeds comparable to those in rolling and the space between them is full of oil, pressures of the order of 100,000 psi can easily exist from simple viscous drag when the surfaces have approached to within about ten microinches of each other. An action similar to this must exist in the immediate region of the roll bite. It is interesting that simple dragging of the oil can pump it into a zone where pressures equal the yield strength of metals, at least.

By the analysis above, much of the pumping action of viscous drag would have taken place after the surfaces had approached to within about 50 microinches of each other. These analyses were for absolutely smooth surfaces. In terms of 10 or even 50-microinch dimensions, however, the surfaces are far from smooth. Probably the high spots of the metal micro-surfaces are already coming in contact long before simple drag effects have pumped up full pressure. Therefore, it is probable that trapping of oil pockets in surface irregularities can occur and that the over-all effect is a complex combination of both drag and entrapment. If most of the oil enters the roll bite by entrapment in the surface irregularities, then variations in rolling speed would have little effect on maximum allowable oil films as was found. On the other hand, the increased maximum oil films found for more viscous oil suggest some sort of drag or pumping action which is variable with viscosity. These conflicting observations have not been reconciled by any complete theory.

There is strong evidence that continuous oil films do not exist in the roll bite except for highly unusual cases. The usual lubricant films probably fill in, more or less, the low spots or pockets in the roll and strip micro-surface, with any high spots or areas left protruding. Friction between these surfaces might then be related to the total oil-flooded area. The general order of coefficient of friction in rolling seems to bear this out, as does the physical evidence of metal to metal contact. If there were a continuous film present such that slip occurred only in the oil, coefficients would be closer to the "hydrodynamic" range of 0.005 or less. However, in most cases, these coefficients are in the "boundary" or quasi-contact range of 0.02 to 0.08 or higher. Metal to metal contact almost certainly exists as evidenced also by the "smut" or fine metal particle generation usually observed in rolling. Viscous, highly experimental lubricants have given coefficients of friction well below 0.005 as calculated by the Stone and Greenberger equation. Possibly, with these unusual lubricants, a complete fluid film did exist in the roll bite. Considerable roll slippage and near freedom from smut were further evidence of the approach to purely hydrodynamic lubrication. In nearly every other case of experimental rolling, even with the viscous fats in high film thickness ranges, the usual smut generation was evident.

An attempt is under way to find theoretical explanations for the speed effects shown in Figures 2 and 3. No explanations could be found in the literature for these effects and some highly unexpected variations in the forward slip or relation of delivered strip speed to roll speed. For calculation, coefficient of friction in the roll bite has usually been assumed to be constant for lack of any specific evidence as to how it might vary. Among other possible premises, it seemed that point-to-point variance in this coefficient might help to explain these experimentally observed effects. This assumption has been introduced into the basic differential equation of rolling essentially in the form used by Nadai.[3] In view of the tedious calculations, a digital computer program was written to solve the equation with any desired variations in friction. A few hours of exploratory calculation, with the assumption that friction is at a maximum in the region of the neutral or no-slip point and dropped sharply with increased rubbing or slipping speed of roll against strip surface, yielded theoretical results which bore a strong resemblance to the speed and slip data from the laboratory mill. Further work on this problem is now in progress.

FATTY OIL LUBRICANTS—BEHAVIOR OF OIL AND WATER SYSTEMS

In view of the widespread practice of lubricating cold rolling of steel, particularly with dispersions of fatty oils in water, some of the problems associated with this and related methods of lubricant application were investigated on the laboratory mill. It is evident from the preceding discussions that, no matter how the lubricant is applied, the extent of lubrication will depend on the quantity of lubricant present on the strip or rolls and entering the roll bite. A basic problem, therefore, when using oil and water mixtures is to ensure adequate deposition of the lubricant from the water carrier. Dispersions of oil in water are only suspensions of oil drops, more or less finely divided. These drops must be made to leave the water and stick to the strip and roll surfaces for any lubrication to result. It develops further that reasonably uniform oil deposition is also needed.

In a typical test the entrance side of the mill was provided with a trough several feet long through which freshly agitated oil-water mixture from the main recirculation system was rapidly flowing. The strip being rolled was immersed in the trough for any desired distance, just prior to entering the rolls. Coefficients of friction corresponding to different oil-water mixtures were calculated from the rolling data as usual.

One of the most important factors among the many influencing oil deposition from a water carrier is the content of surface active agents or emulsifiers. All emulsifiers when present in excess seem to prevent oil drop coalescence and adequate oil deposition. While some are either ineffective or harmful throughout an addition range, others are beneficial in small amounts.

Figure 4 plots content of a typical suitable emulsifier, in a 2 per cent by weight dispersion of a natural animal fat in water at 120 F, versus coefficients of friction obtained on the mill. The mill was operated at 1000 fpm, rolling 0.0063 x 0.250-in. steel strip with 3200-lb rolling

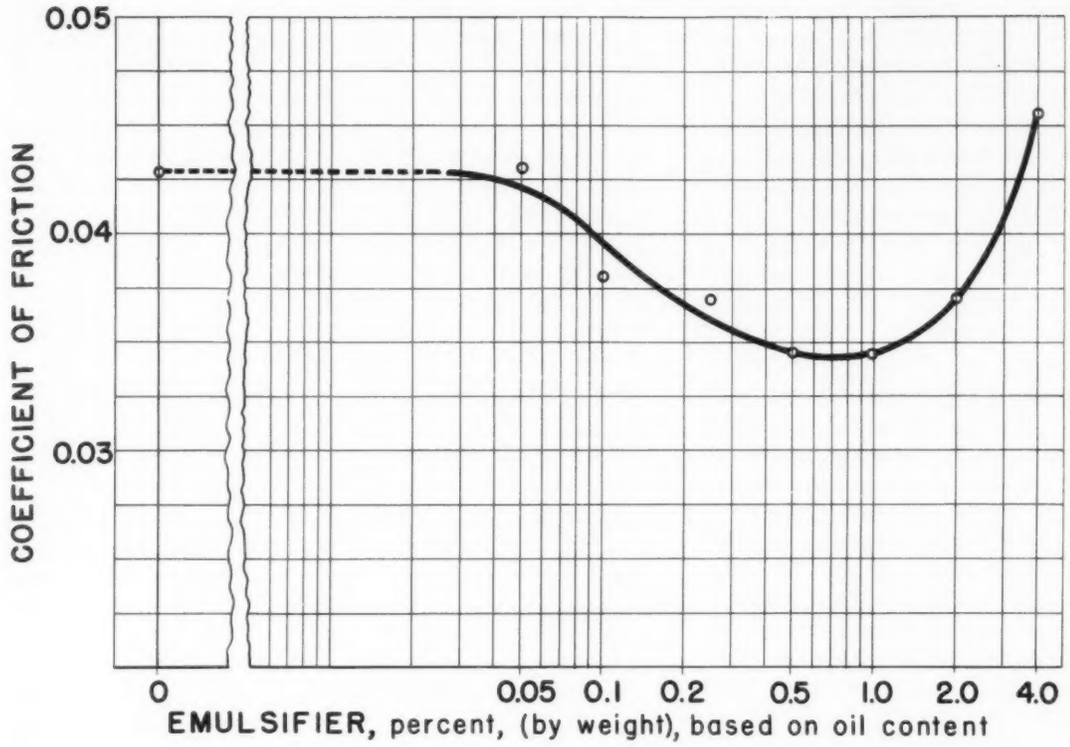


Figure 4 — This curve compares coefficient of friction vs emulsifier content for 0.0063 x 0.250-in. steel strip being rolled at 1000 fpm.

load, giving reductions of 20 to 30 per cent. Figure 5 shows emulsifier content vs oil film deposited on strip which was simply pulled through the oiling trough and not rolled. This strip was immersed in the oil-water dispersion for 0.3 sec, moving at 550 fpm. Oil film measurements were obtained by the degrease procedures previously described. The oil-water mixture, temperature and choice of emulsifier were the same for both Figures 4 and 5. In both cases also the strip used had been previously oiled with a very thin film of the same oil to ensure oily surface only. This amount was subtracted from quantities shown in Figure 5.

These data show that emulsifiers, to a rather surprising extent, influence lubrication and hence friction through a mechanism of oil deposition or release of oil from a body of water. It is interesting to note, in Figure 5 the effect of only 0.003 per cent emulsifier. The maximum oil deposition at 0.05 to 0.06 per cent is about twice that for no emulsifier dropping again with still more emulsifier. In Figure 4 rolling data showed the lowest coefficient of friction was obtained with 0.7 per cent emulsifier. Although the maximum oil deposition occurred at 0.05 per cent emulsifier in Figure 5, visual comparison of strips oiled at the two levels showed that more emulsifier gave a much more uniform coating of oil although the total quantity deposited was less. The comparison points to the need for uniformity in oil deposition, as well as quantity.

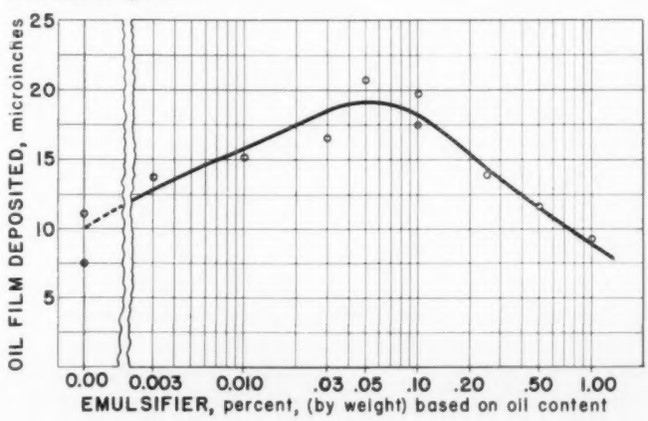
Improvement in lubrication efficiency, when using almost any type of lubricant mixed with water, could be gained by running the strip between two wooden dowel rods on the way to the rolls. These rods, clamped lightly together, served as rudimentary scrapers, tending to smooth out oil film unevenness. Results obtained in both Figures 4 and 5 were obtained using this device. Coefficients obtained in the case of Figure 4 without the smoothing device, were uniformly 0.004 higher, with a minimum of 0.039, compared to the minimum of 0.034. These results also point to the need for lubricant film uniformity.

Other factors influencing the deposition of good oil films were the time of immersion of the strip, the degree of agitation, and the temperature of the dispersion. The optimum emulsifier content varies somewhat with these quantities.

With a variety of oils and emulsifiers the best rolling mixtures had a similar appearance. They formed dispersions of small oil drops easily with agitation but broke rapidly on standing leaving fairly clear water below. The milky look obtained, for instance with a typical "soluble" oil, while indicative of a more stable emulsion, rarely indicated good rolling. Such visual inspection is useful but no substitute for actual mill tests.

The best obtainable dispersions of fats in water gave results on the mill which approached but never surpassed results obtained with excess oil on the strip, and water on the rolls. This applies to both types of fats.

Figure 5 — This curve of oil film deposited on strip vs measured emulsifier content was compiled from a test in which a strip was pulled through an oiling trough in 0.3 sec at 550 fpm.



The more viscous modified types retained their relative superiority. For example, with rolling conditions as explained for Figure 4, with an excess of the particular animal fat on the strip and water only on the rolls, the coefficient of friction obtained was 0.032. The lowest coefficient observed in Figure 4 is 0.034. A typical coefficient for the conditions of Figure 4 and using the viscous fat of Figure 3 suspended in water would have been about 0.029.

SUMMARY

The laboratory results presented, although far from completion, suggest various approaches to improvement in practical rolling lubrication. This discussion is concerned specifically with the frictional properties of lubricants. Other matters, such as cost, convenience of use, and ease of cleaning from the strip, can rarely be ignored. However, mill operators can usually evaluate these factors for themselves without too much trouble. In general, improved lubrication can offer benefits to any rolling job where friction is a limiting factor. The thinner and harder the strip, and the larger the rolls, the more likely this is to be the case. All too often, though, it is assumed that one oil is about like another. For many jobs this is true, but in other cases it may not be realized that benefits of the sort implied by Figure 1 and Table I are available. Frequently, a change from a mineral type oil to any fatty material would work wonders. For very difficult problems the less well known materials, such as the water soluble group, may prove of value.

Friction effects on any job can be roughly estimated. The rolling load is not often known with any accuracy in practice. However, by using the known dimensions and properties of rolls and strip in the equations and nomographs of the Stone and Greenberger references, it is relatively easy to calculate the ranges of coefficient of friction which will give minimum, moderate, or impractically high loads for the job at hand. From various published data, estimates of the coefficient of friction for various lubricants can be made. Often at this point it will be clear to the operator whether or not improved lubrication will be of any value.

Because so much of the experimental work was done with fatty oils on steel strip, conclusions are particularly applicable to mills such as those rolling tin mill black plate where such oils are universally used. Friction on these mills is a recognized problem. Although further suggestions on lubrication often refer specifically to these mills, the comments are generally applicable.

The problems associated with the improvement of lubrication for mills employing fatty oils suggest, in the opinion of the authors, basic inadequacies not only of the presently used oils themselves but also the methods of their application. Two commonly used methods of lubricant application to tandem tin mills, the so-called direct application and recirculating solution systems suffer from common faults. In direct application methods, the practice of applying mixtures of oil and water to strip flooded with water makes this system very similar to the solution method. Either way, the oil must get from the water onto the surface of the strip or rolls uniformly, in adequate quantity and in a very short time. As pointed out under the discussions of oil deposition from water, any system employing water as a carrier for the oil is subject to many changes in the surface chemistry of the system, greatly affecting oil deposition. If every factor is working right and adequate deposition occurs, the oils thus employed can be used to the limit of their inherent qualities. However, apparently very slight changes in any of a number of unrelated factors can markedly change the oil deposition rate, quantity, uniformity of deposition, and thus the quality of lubrication afforded. In addition mill cooling suffers. Where hot steel surfaces are cooled by water, the presence of several per cent of dispersed fat in the water reduces the cooling rate by about one-third.

The ticklish nature of the over-all oil and water competition problem is evident in the day-to-day or even hour-to-hour variance in lubricant performance often experienced by operators of many large tandem mills. The trends away from the use of palm oil and the acceptance of proprietary blends based on animal fats are due somewhat to problems of this sort. In laboratory experience there was no measurable difference between the performance of palm oil, animal fats and several representative commercial products so long as adequate oil quantities were present on the strip. However, to enable typical animal fats to perform as well as these commercial products over a broad range of conditions, proper emulsifier addition was required. Practical solutions to some of these surface chemistry problems seem to account for the wide acceptance of these present day compounded oils. It is expected that improvements will continue along these lines. Extensive testing of proposed improved mixtures proceeds steadily throughout the industry. However, improvements by this means will approach as a limit the performance of the fats used in compounding. Probably no really major advance can be achieved unless the base oils themselves are improved either along lines of chemical polarity or what now appears more feasible, by modification of physical properties such as viscosity.

Improved lubrication using fatty oils would require the application of two principles: first, to stop using water, particularly cooling water, as an oil carrier; and secondly to directly apply to dry strip or rolls controlled quantities of lubricants, including improved types where needed, with due regard for over-lubrication or skidding potential.

The lubricant application requirements might be met by air-powered spray devices such as used in paint guns. The air blast would assist in removing water from the strip in the immediate area of the spray. These devices spray quite uniformly and probably are easily controlled and metered as to quantity. This application method has been successfully piloted on the laboratory mill.

The amount of oil necessary to roll any particular job could be readily estimated by comparing oil film measurements on rolled strip with mill performance. With tandem mills, of course, only the last stand performance could be followed without special procedures. Thin oil films could be used where adequate, such as on the earlier stands of a tandem tin mill or possibly through out on a sheet mill. Oil economy and less danger of skidding from inadequate friction grip would follow. Of interest also, in this connection, is the observed effect in the laboratory of less speed on thin oil films. This sug-

gests less off-gage strip due to acceleration and deceleration speed effects if thin oil films and their higher friction could be tolerated. On the final stands of a tandem tin mill, however, the lowest possible friction can be used without much danger of losing frictional grip. Here, by spraying heavier films, the minimum friction possible with the particular oil could be achieved. Here also the use of improved lubricant types, such as the more viscous fats, would permit very low friction. Or, if very low friction is not required, the use of these viscous materials would permit previous friction levels to be maintained with less oil consumption.

The over-all advantages of controlled oil use would include economy of oil consumption in that only the oil actually required for rolling plus any necessary excess would be consumed. Unprecedented uniformity of operation would result entirely within control of the operators as to level of friction desired. With the cooling water free of oil contamination, much better mill cooling will be evident.

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Discussion

PRESENTED BY

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M. D. Stone: For some years we have formulated ideas for a rolling theory, but when one reads Mr. Jortner's[4] work he will see that our ideas have been quite simple, relatively speaking. Our rolling parameter has been M, the friction of the roll bite, times L, the contact length of the flattened roll, divided by the thickness of the strip being rolled, t, i.e., ML/t. Mr. Jortner's work has more or less concentrated on a more accurate determination of L, and Whetzel's and Rodman's work is a real study of what factors influence M. Practically speaking, I think that we are more satisfied without approximate notions of L than we are with what determines and influences M.

About ten years ago Battelle[5] determined, primarily, the friction coefficient. They used a small mill and evaluated these average coefficients to considerable advantage. Rolling tests at U. S. Steel Corp. Irvin Works, some years ago, were the first to conclude that there was a very significant relationship between speed of rolling and friction in the bite, but they did not understand why it was so great.

I was particularly impressed with the correlation between the thickness of the film and the friction coefficient. We had always assumed it was similar to a hydrodynamic effect. Maybe it still is, but we had no detailed notions such as this paper shows. As the authors pointed out, even for a uniform thickness of film, there is a decided speed effect. In this connection, I might call attention to the fact that in the early days of railroading, when they were trying to evaluate tractive efforts and friction coefficients between wheels and rails (which were obstensibly dry friction, although you cannot always get all the adhering films off), they also found a definite relationship between speed and friction for even dry rolling. This may add a point or area to the series of curves in Figure 3.

Referring to Figures 4 and 5, Figure 4 shows a minimum coefficient of friction at an emulsifier content of around 0.7 per cent, whereas Figure 5 shows a maximum film deposit at an emulsifier content of about 0.06 per cent—a ratio of around 12 to 1. Am I correct in understanding this? I would have suspected from what you previously have shown that they would more or less coincide.

J. C. Whetzel, Jr.: The lack of coincidence observed in Figures 4 and 5 resulted from one emulsifier content producing a minimum coefficient of friction while another level produced maximum oil film deposition. In Figure 4 the emulsifier content which produced the lowest coefficient was 0.7 per cent based on the oil. In Figure 5 maximum oil film deposition occurred at 0.06 per cent, about $\frac{1}{12}$th of the former level. This appears to be an exception to the "rule" of more oil, better lubrication. The reason for the discontinuity seems to lie in the uniformity of oil film deposition. At the higher emulsifier level of 0.7 per cent, visual inspection of oiled strip, which had not been rolled, showed much more uniform oil film deposition although, by actual measurement, less in total quantity. In the lower emulsifier content range, deposited oil films were discontinuous with the appearance of large lumps interspersed at irregular intervals along the strip. At the rolling speed employed, 1000 fpm, there would not have been time for redistribution of the oil, and thus the strip appeared in the roll bite as alternately well oiled and relatively dry sections. This discontinuous lubricant film gave poor average coefficient of friction and hence poor reduction.

D. J. Gerhardt: How do the authors measure the thickness of the oil film in microinches which is left on the strip after cold reducing?

Is there a great deal of difference in the coefficient of

friction when using cast iron rolls as compared to forged steel? Practice does not necessarily indicate so.

Water soluble chemical lubricants sound as if they could be used to improve the lubricity of some of our detergents to make them better rolling solutions. Is this a possibility?

The paper indicates that in direct application the oil is applied to a strip flooded with water, and for that reason it is considered inadequate. Actually we take the water off the strip with a tension and damming roll so it is relatively free of water. Also the water for cooling the top roll is applied on the delivery side of the mill instead of the entry side so that the oil on the top of the strip is not diluted or washed off.

Air sprays would atomize the oil too finely. The air surrounding the mill would be filled with finely atomized oils which would cover everything and would also be very objectionable for personnel.

J. C. Whetzel, Jr.: There is a rather simple technique for measuring oil film thicknesses. The problem essentially is to acquire a known area of the strip in question and remove the oil film by degreasing. One way is to cut it into little pieces and then successively wash the pieces in a beaker with a very clean solvent, such as freshly re-distilled hexane. Collect the washings and determine the oil contained in the solvent gravimetrically by evaporation in a tared beaker or other small container. For our measurements we used 75 sq in. of strip, total surface of both sides, and the oil amounts ranged from two to about 15 milligrams. Knowing the specific gravity of the oil used, we could then calculate an average film thickness over the measured area. I might mention that the technique described completely removed all oil, but left behind adhering to the strip most of the "smut" generated in rolling.

We believe this is a technique that could be used in mill testing work to help investigate rolling oil performance. It would give you a little more grip on what one oil is doing for you as compared to another.

We have only one set of rolls and they are forged low alloy steel, hardness Rc 66–68. Therefore we have no experimental information on the use of iron rolls.

The third question deals with possible incorporation of water soluble lubricants in detergent compositions. This approach to increasing the lubricating value of some detergent compositions probably will not work. Nearly all the water soluble lubricants seem to lose their ability to lubricate when dissolved in dilute water solution.

The fourth question concerns our objections to rolling lubrication by direct application methods. We feel qualified to discuss this controversial subject from a theoretical point of view only, having had little practical experience on large production mills. Fatty rolling lubricants are often directly applied to the strip as a concentrated suspension of fat in water, for example one part oil and four parts water. The fact that the two are mixed before application to the strip means that competing forces will exist between oil and water as to which will preferentially wet the strip. Or, stated another way, these forces will determine how much oil will wet or deposit on and stick to the strip in a specific period of time, usually a small fraction of a second. Possibly, in a concentrated suspension with an oil content of 20 to 25 per cent these surface active effects will be less important than in dilute systems where the oil may be only 5 per cent of the total mixture. But these effects are strong enough and sufficiently variable as to affect the uniformity and amount of lubrication afforded by lubricants applied in this manner. We believe it would be better to somehow avoid completely any mixing of the oil with water prior to application. In any event, application of lubricants either dry or in water suspension should be made to the strip as free of water as possible. The practice described by Mr. Gerhardt is good in this respect and is better than some methods we have seen.

We recognize there will be a number of engineering problems with an air-spray lubrication method. We present this idea as one approach to the end result of oil economy and good control over rolling lubrication through control of the amount of lubricant applied.

Sidney A. Paradee: I would like to ask if it is felt that adding an emulsifier to a fatty oil has improved the polar characteristics of the oil at 0.7 per cent? Also, is it felt that increasing the emulsifier content destroyed the polar characteristic and thereby increased the coefficient of friction?

In answer to one of Mr. Gerhardt's questions, air spray application has been tried, but because of the inadequacy of the exhaust systems normally used on mills there is a tendency to coat every part of the mill with oil. In the case of palm oil, it caused the mill housings to appear as if they were painted yellow.

J. C. Whetzel, Jr.: I do not know whether we would want to call the action of an emulsifier a change of "polarity" or what name we should give it. We believe the effect of emulsifiers, in addition to many other surface active effects, is to regulate the method and degree of oil deposition or release onto a surface from a mixed oil-water system. We do not believe emulsifiers improve the basic lubricating value of a particular oil. They simply make the oil more or less available for lubrication. As shown in Table I, we believe there is little difference between them for rolling steel so long as they are present in adequate quantity and so long as their physical properties are such that they are roughly similar.

Of course, this is a very complex subject. There are many other surface active effects which will change the lubricating characteristics of an oil-water system. We have used emulsifiers as illustrative of only one of these many effects.

R. P. Schuler: Mr. Whetzel spoke about the direct application of rolling oil to the sheet by the use of air, i.e. the oil is applied as a fine mist. I would like to ask Mr. Whetzel if he has ever tried applying oil electrostatically to the strip.

J. C. Whetzel, Jr.: No, we have not tried any electrostatic techniques, but we have tried two air-powered systems on the laboratory mill. One was an air-aspirated system such as used in air-powered painting equipment. The other was an oil fog mechanism such as is manufactured for transporting measured amounts of lubricants to bearing surfaces. The particular fog system at hand suffered from insufficient lubricant delivery. With adequate sized equipment we believe either system would work satisfactorily if the other problems of surrounding air pollution could be solved. ▲

MANY CIRCUITS OVER TWO WIRES

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. . . . installation costs can be reduced by using existing wires for transmission of control signals required by new equipment . . . .

ALL industries today are looking for ways and means to make their operation more efficient and economical. Each department must take a close look at existing facilities to see if ways can be found to combine operations or to improve existing units. When new facilities are installed, all means must be considered to make the new installation as economical as possible. Automation and remote control systems are one answer to this problem.

When planning an automatic system installation the entire cost must be considered before management knows whether a savings has been made. This cost includes new equipment purchased, existing equipment revised, and the installation of the equipment. The first two costs are set by the type of system desired, but the important variable factor is the installation. Many times a very worthy project has to be abandoned due to the high cost of installation. Many engineers say they have no space remaining to run the necessary wires, and that labor costs are greater than the equipment involved.

This area of proposed installation should be seriously studied since the resulting savings can be a high percentage of the over-all job costs. Many circuits over two wires is the answer to the high installation cost of remote control systems.

This discussion covers how an installation is made and not necessarily what operation takes place. It makes little difference whether you are controlling pumps, valves, motors, overhead cranes or complete processes, a transmission path must be available between the control pulpit and the object to be controlled. If both locations are on the ground, control wiring can be used for this transmission circuit; and if overhead cranes or other moving electric machines are involved, then cable reels or collector rails are required. The installation of control cables and collector rails are both time consuming and costly. Important savings can be made if equipment is available to replace the cables and rails.

Reliability, dependability, simplicity and versatility are a must for the equipment. Transmission circuits must operate under dirty, dusty, noisy conditions, continuously 24 hours a day. Required maintenance must be held to a minimum, and only a minimum of parts should be used in the equipment. The system should be designed to be as flexible as possible. Control and indication circuits should be available to add to the system or to change as the need arises. All units should be plug-in connected to aid the maintenance man in trouble shooting. These are some of the requirements that transmission equipment must meet before being considered in remote controls.

Some of the equipment available for transmitting remote control signals includes first, carrier current systems that operate over existing a-c or d-c power lines; for which no new wires are required. Carrier current is a radio frequency signal between 10 and 200kc. A single control channel can be provided by keying a transmitter on and off so that a relay, at the receiver location, will operate as the transmitter is keyed. This is a basic on-off carrier current control system. The carrier frequency can also be shifted 3kc or 3 per cent on either side of the center frequency to provide two on-off channels for control. Multiple control channels are obtained by modulating one carrier frequency with up to ten audio tone frequencies. This would provide ten channels for simultaneous operation. The ten tone frequencies can also be used in coded combinations to provide many more circuits (55). This system has been used successfully for controlling circuit breakers and in supervisory control systems.

Relay control systems also can be transmitted by carrier shift transmitters and receivers. Since the carrier shift provides two independent channels, it can be used to either energize or de-energize a relay circuit as the frequency is shifted up and down. Pulses can be sent from a transmitter to operate a stepping switch at the receiver location. In this manner either 25 or 50 different operations can be selected and then controlled. After selection is obtained, the shift-up pulse can be used as an "on" control and the shift down pulse as an "off" control. Two independent controls are thus available for 50 selected functions. An application of this system is for controlling individual soaking pit covers from overhead pit cranes and also for opening and closing furnace doors on reheating furnaces from the charging machines.

A second and faster type of relay system can be operated over one carrier shift channel. This is a relay counting chain transmitter and receiver. Here a counting chain of 20 relays are set up with an operating speed of $\frac{1}{3}$ sec. Twenty on-off circuits can then be controlled in one cycle of operation or $\frac{1}{3}$ sec. Now, if more controls are required, this can be provided by

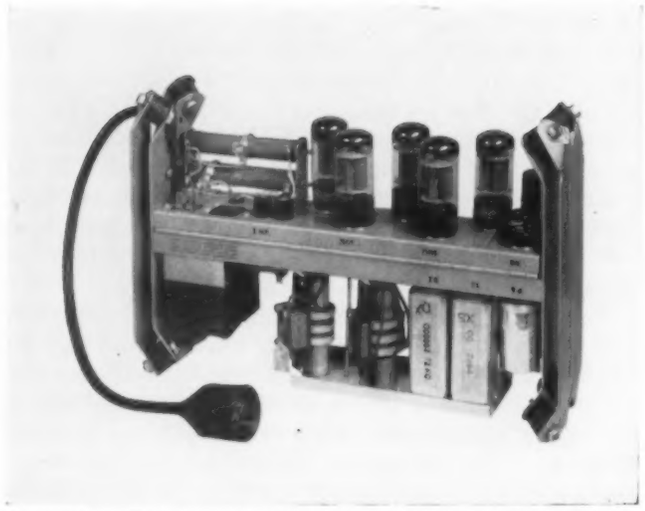


Figure 1 — This carrier shift transmitter, with its receiver, provides an interlock signal for coke oven machines and ore bridges.

combining groups of the 20 relays in a binary code. For example, the 20-step chain can be divided into five groups of four relays each. Each of the four relays in binary code will provide 16 on-off circuits or a total of 80 on-off circuits in $\frac{1}{3}$ of a sec. To put this system to use, consider a standard magnetic controlled, overhead crane with hoist, bridge and trolley. Four counting chain relays would be used for hoist, four for bridge and four for trolley, or 12 out of the standard 20-step unit. Since each of the four relays provide 16 on-off circuits, there would be more than enough available to replace the wires between the standard controllers and the magnetic panels. This system is being used to control overhead cranes from the floor. It provides the same controls and speed points as is customarily used in the crane cab.

These relay systems, which work over carrier channels, can also be used over a simple 2-wire telephone circuit between fixed locations. The systems are identical with the carrier shift, being added or omitted as the installation demands.

Audio tone channels, which were described for modulating carrier units, can also be used over 2-wire circuits. Standard class A telephone circuits are used as transmission paths for 24 audio tone channels. Since tone channels are in the audible range, voice cannot be used over the same telephone circuit.

Circuit scanner systems are another method of providing many circuits over two wires. Circuit scanners are synchronous motors that revolve a magnet past hermetically sealed reed switches. In this manner 22 circuits are available in each revolution. The remote

Figure 3 — This relay transmitter, with its receiver, provides remote control of overhead cranes and soaking pits.

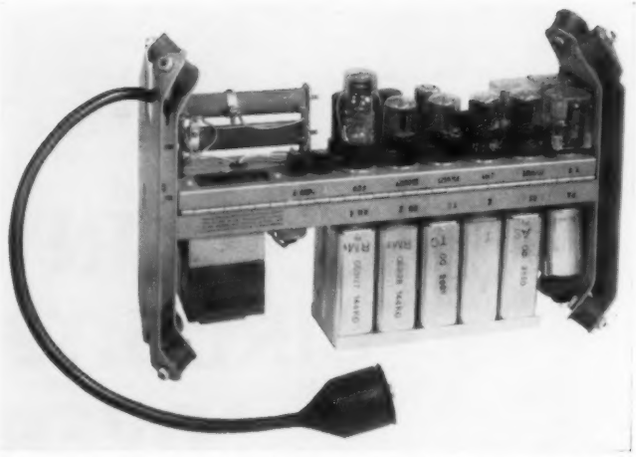


Figure 2 — The carrier shift receiver for the transmitter in Figure 1.

and local scanners are kept in synchronism by the 60-cycle power line frequency so that each scanner is passing the same contact point at the same time. An on-off channel is thus set up on each point of the 22 available as the magnet passes that particular reed switch. When they are in synchronism, four separate impulses, each at the proper time, polarity and space must be received to make a change. This checks against random noise on the line. Control time is abut eight sec. The scanner is a very reliable unit because it is a non-contacting switch that operates strictly on the magnetic principle. The scanner has been used for controlling pumps and valves in water systems, for alarm circuits, programming and many other applications too numerous to mention. Each application determines the speed of the scanner units with standard speeds of $\frac{1}{2}$, 1, 2, 30 and 100 rpm available.

All of the different systems described are compatible and can be used on the same two wires at the same time. Audio tones and circuit scanners can operate at the same time over a telephone pair to provide hundreds of on-off channels. Many carrier channels can operate over the same power line at the same time without interference.

The carrier shift transmitter, Figure 1, and receiver, Figure 2, can be used with any of the control systems to provide operation over power lines. Installations using this type of equipment are in operation in many steel plants for controlling individual soaking pit covers and cover carriage cranes. The relay transmitter, Figure 3, and receiver, Figure 4, combined with the carrier shift transmitter, Figure 1, are used for operating cover carriages from the overhead pit cranes. The overhead

Figure 4 — The relay receiver for the transmitter of Figure 3.

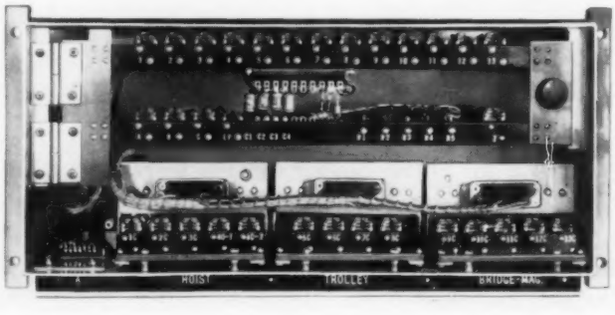


Figure 5 — This office circuit scanner and a similar one located in the field provide multiple control of substation breakers, water pumps and valves, gas valves, etc.

crane operator then can select any position for the cover crane and operate the travel motion and the hoist while moving or standing still. This system can be set up so as to be automatic in selection and spotting or manually remote controlled. This system provides the most economical and most efficient operation of the soaking pit area in steel plants.

Audio tones and circuit scanners, Figure 5, have been primarily used for remote indication and control in instrumentation applications. In one instance the circuit scanner is used to operate gas valves and bring indications of this operation back to a central display console. Audio tones are used on the same pair of wires to provide telemetering of natural gas and plant gas pressures. Over one pair of wires eight control circuits, 16 indication circuits and three telemetering channels are provided.

In another application audio tones and circuit scanners were combined to telemeter coke plant stack and draft pressures and to control and indicate the reversing operation on the coke ovens. In this application over one pair of wires, 10 telemetering circuits, 12 indication circuits and four control circuits were provided.

Audio tones have been used alone in many applications that require multiple circuits over one pair of wires. The indication of the operation of nine quenchers in a coke plant was transmitted and recorded on a strip chart over one pair of wires. There are many other types of applications for telemetering using audio tones.

The circuit scanner also has been used for applications in steel plants without any additional control equipment. It has been used to control water systems that are remote from the plant location. Annunciator circuits for substations have been transmitted over one pair of wires to the central maintenance shop. Circuit scanners alone can be used for many applications of remote control and indication with one pair of line wires.

This equipment has been used in the past to provide more efficient and more economical operation in steel plants. Its future use is only limited by how much industry wants to progress in making their operations more efficient.

Many circuits over two wires is the answer to practical low cost remote control systems. The use of electronics and remote control systems make many of the dreams of yesterday the realities today. ▲

Figure 6 — Multiple telemetering channels over a single pair of wires is provided by this audio tone oscillator and a filter.

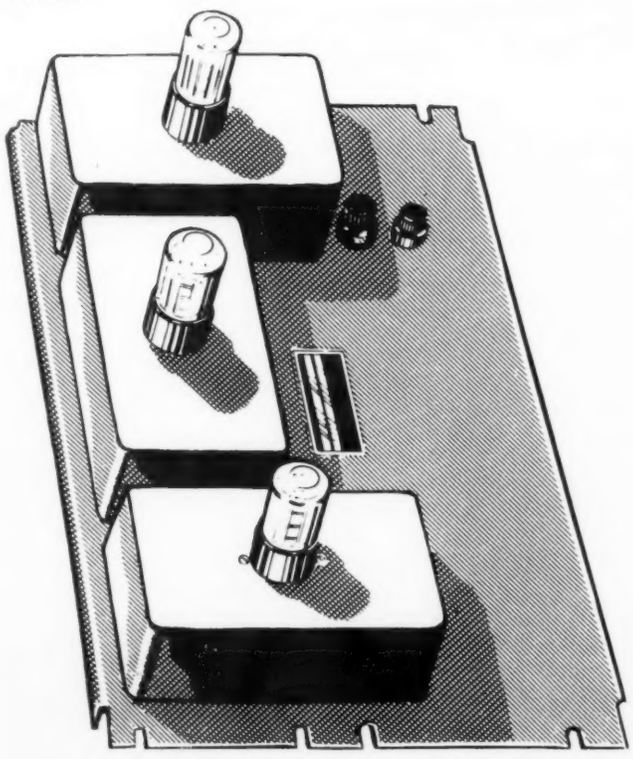
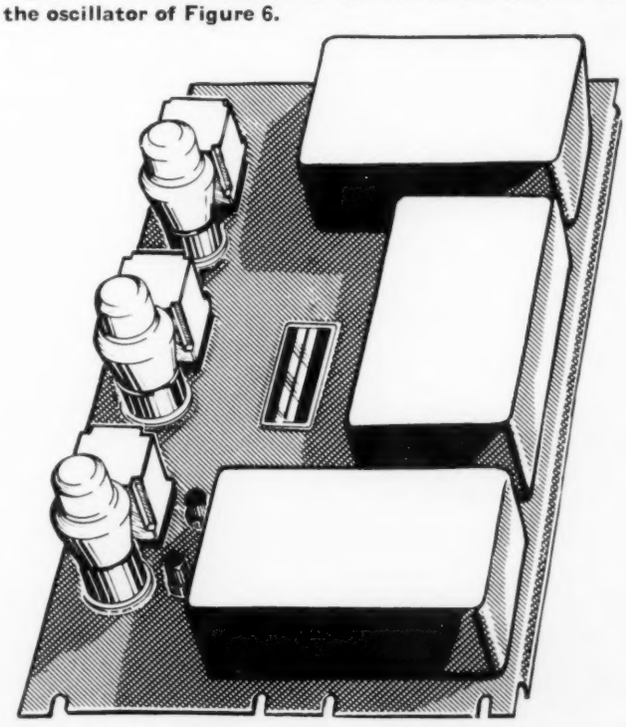
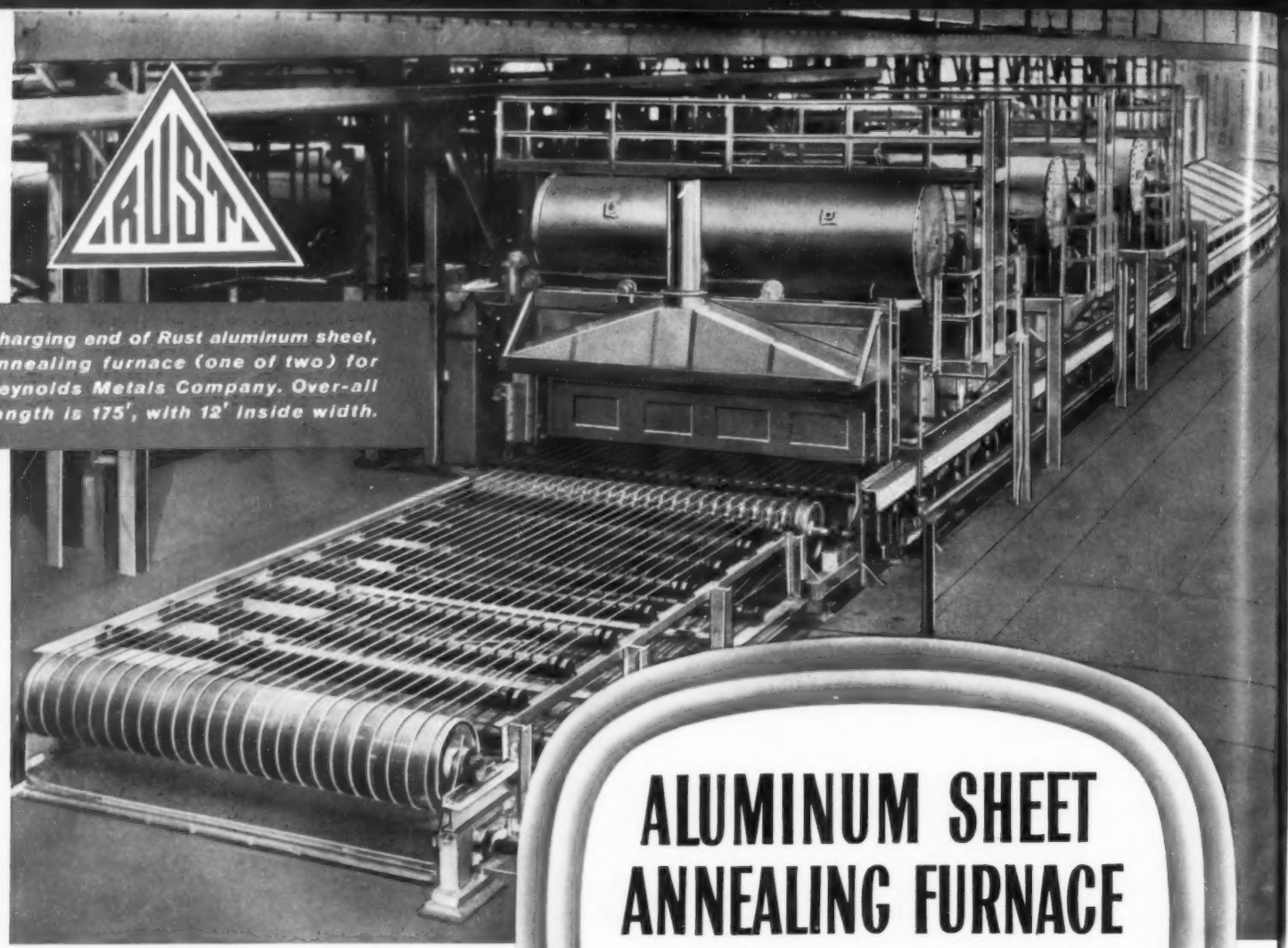


Figure 7 — This audio filter is used in control systems with the oscillator of Figure 6.

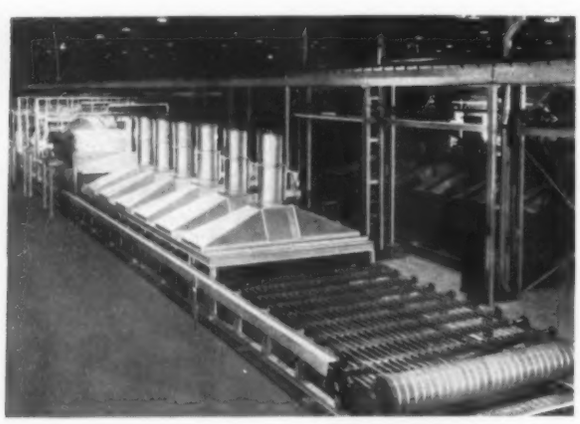




Charging end of Rust aluminum sheet, annealing furnace (one of two) for Reynolds Metals Company. Over-all length is 175', with 12' inside width.

ALUMINUM SHEET ANNEALING FURNACE

with new type of band conveyor designed and constructed for Reynolds Metals Company, Listerhill, Alabama.



Discharge end of annealing furnace. A new type band conveyor minimizes the marking of the aluminum sheets.

This modern Rust furnace is designed to anneal hourly 12,000 lbs. of aluminum sheets, 0.01″ to 0.25″ thickness in random sizes up to 144″ wide. A new type of band conveyor minimizes (often completely eliminates) marking of the aluminum sheets by the furnace conveyor. Individually tensioned stainless steel bands are spaced to accommodate a variety of sizes and shapes of aluminum products.

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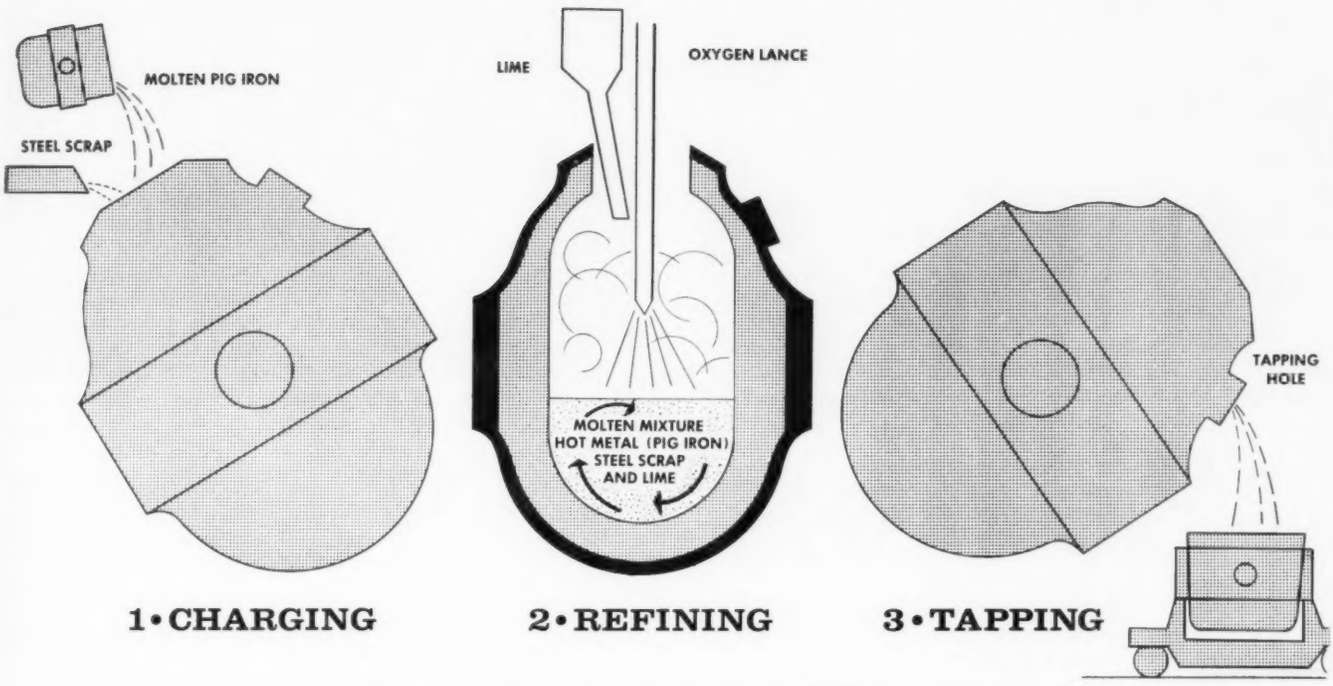


Figure 1 — Steps in the basic oxygen steelmaking process.

Kaiser's Oxygen Converter Start-Up Marks Completion of Expansion Program

A NEW era in Western steelmaking began on February 1 when the first official heat of 100 tons of steel was poured from Kaiser Steel's new basic oxygen steelmaking facilities. Kaiser Steel's three oxygen furnaces, with an annual rated capacity of 1,440,000 tons, comprise the largest steelmaking installation of this type in the world. Each furnace is 26 ft high, and 18 ft in diameter. A complete cycle takes about an hour. It is the first oxygen steelmaking installation in the West and the third such facility to be built in the U. S.

The dedication of the new steelmaking plant marked the completion of all the major facilities in Kaiser Steel's $214,000,000 expansion program which has been under construction for two and a half years. The expansion virtually doubled Kaiser Steel's annual ingot capacity, from 1,536,000 tons to 2,933,000 tons, and makes the Fontana plant the largest steel mill west of the Mississippi.

In addition to the basic oxygen steelmaking plant, the expansion has included a fourth blast furnace, a

Figure 2 — This is the basic oxygen steel plant, which houses Kaiser Steel's three new furnaces. The structure to the right of the main building, marked by the three stacks, houses what is probably the world's largest electrostatic precipitator, built at a cost of nearly $5,000,000.

Figure 3 — Tilted forward in its charging position, one of the furnaces receives molten pig iron. This is followed by a charge of scrap steel. The oxygen furnace is then returned to an upright position, where it is charged with lime. Then a jet stream of oxygen, blown upon the surface of the molten metal, starts the refining process which takes less than 30 min. The furnace is then rotated to the pouring position and the molten steel is tapped into a ladle through the tapping hole.

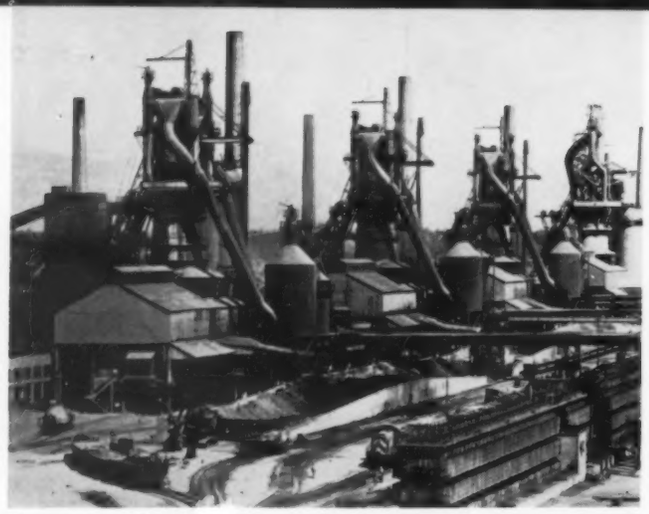


Figure 4 — The West Coast now has four blast furnaces, all located at Kaiser Steel's Fontana, Calif., plant. The fourth—and biggest—blast furnace (far right) was recently put into operation. Some 232 ft high, the new blast furnace is designed to produce approximately 1750 tons of molten pig iron per day. This increases Kaiser Steel's annual pig iron (hot metal) capacity from 1,314,000 tons to 1,912,000 tons.

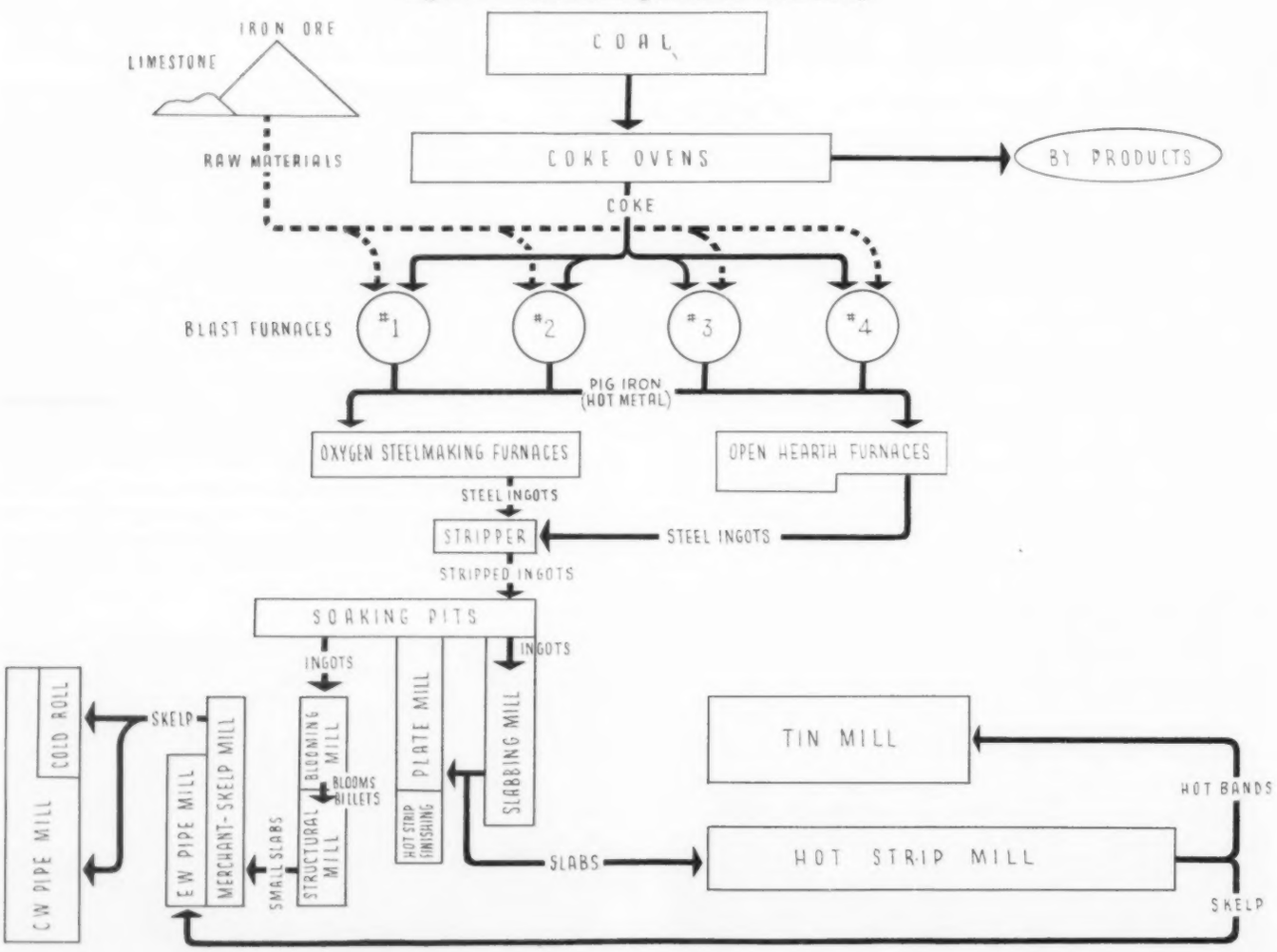
Figure 5 — Kaiser Steel's new hot strip mill is housed in a building more than a half mile long, and covering eight acres. The steel slab travels from the furnaces at one end of the building, through the 11 rolling mills to the coiler at the far end, a distance of 1245 ft, in just two minutes. A typical slab—40 in. wide, 4 in. thick, and 22 ft long—completes the journey as a coiled sheet about a quarter of a mile long.

new slabbing mill, a new hot strip mill, 90 additional coke ovens, extensive additions to the tin plate mill, new facilities to produce wider steel plate, and improvements at Kaiser Steel's company owned mines at Eagle Mountain, Calif.; Sunnyside, Utah, and Raton, New Mexico.

An integral part of Kaiser Steel's new oxygen furnaces is the world's largest electrostatic preciptator, designed to control smoke generated in the oxygen furnace process. The precipitator, built at a cost of nearly $5,000,000, incorporates all of the known techniques in smoke control.

The oxygen steel plant at Fontana will augment the production of steel ingots from the existing nine open hearth furnaces. Steel produced in both shops will be fed into the plant's ten rolling mills which produce a wide range of semi-finished and finished steel products. ▲

Figure 6 — Steelmaking at Kaiser Steel today.



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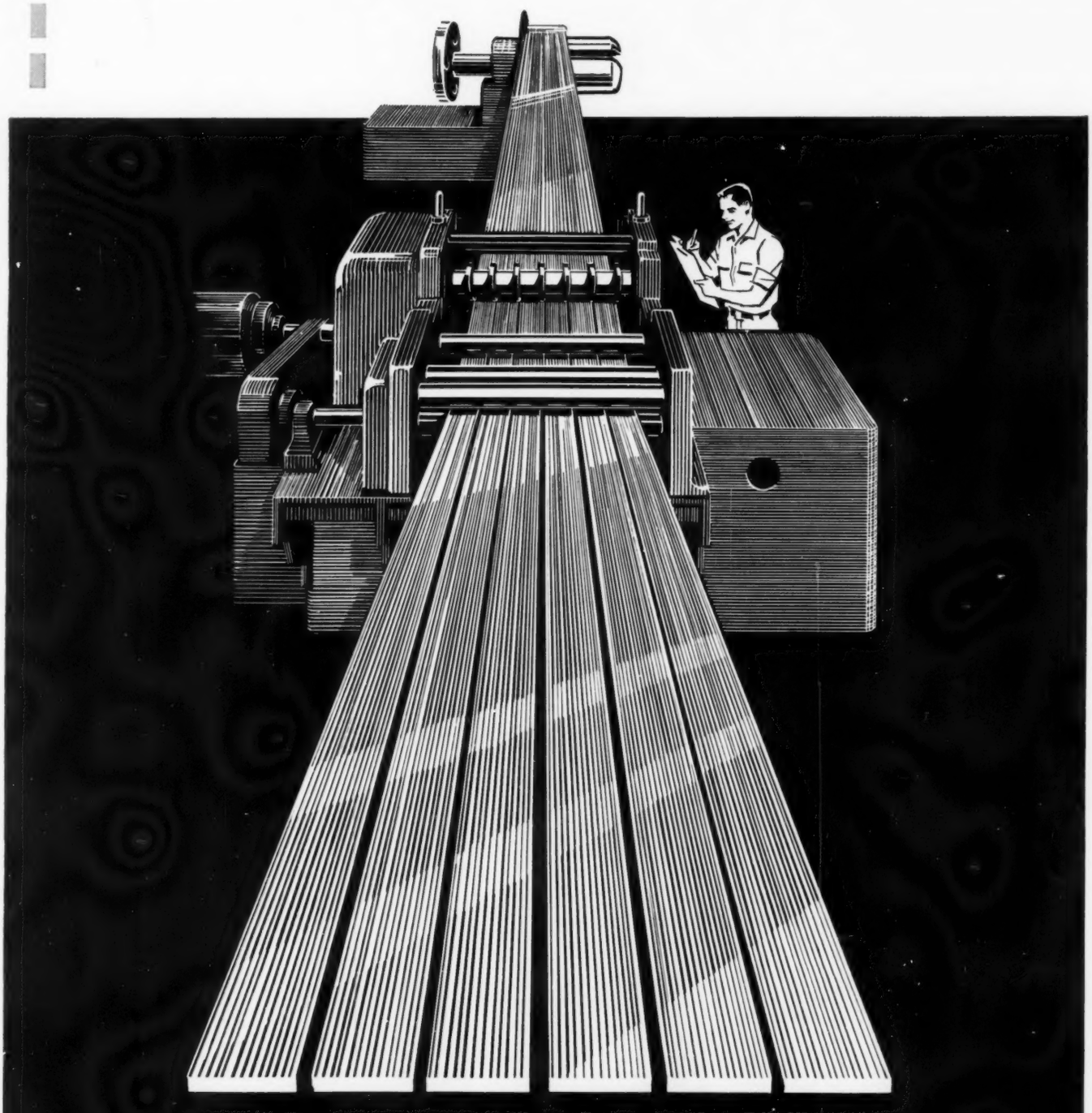

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U.S. Steel Announces Production of Vinyl-Coated Sheet

A NEW product which will promote usage of steel sheet is a vinyl-coated sheet recently announced by the United States Steel Corp. The new product comes as the result of a long-term development program and completion of facilities for producing the product at the Irvin works.

The primary advantage of the new product is its decorative value—both from the colors available—and from the precise textures embossed in the coating.

The coating is mechanically tough, abrasion and scratch resistant. It is chemically tough—resisting stain and corrosion from a wide variety of common chemicals in a manner far superior to normal paint finishes.

It has electrical toughness, with a dielectric strength of approximately 750 volts per mil of coating thickness.

In line with its decorative values is its tactile quality or its "feel." It has a soft quality associated with leather or tweed materials—a far cry from cold metal.

There are many other qualities such as cleanability and formability.

The product is produced as follows:

1. Cold rolled or galvanized sheets in coils are fed into a cleaning unit where all traces of foreign material are removed.

2. The strip then proceeds into an electrochemical treating unit where a slight etching of the surface occurs and a slight chemical deposit is made.

3. The next step is to roller coat the sheet with thin film of thermosetting adhesive.

4. The strip then passes over another roller coater where a suitable primer material is applied to the reverse side of the sheet as a corrosion protection. This step may be eliminated if not required by a customer.

5. The adhesive and the reverse surface protection are simultaneously cured in an oven.

6. The liquid vinyl is then applied by a reverse roller coater and is heat cured on the steel to produce a permanent bond.

7. While still hot, the steel strip passes through embossing rolls where the texture is impressed in the vinyl. After cooling the product is either coiled or cut to length.

The product resulting from this process thus has the strength of steel combined with the decorative and functional aspects of vinyl plastics.

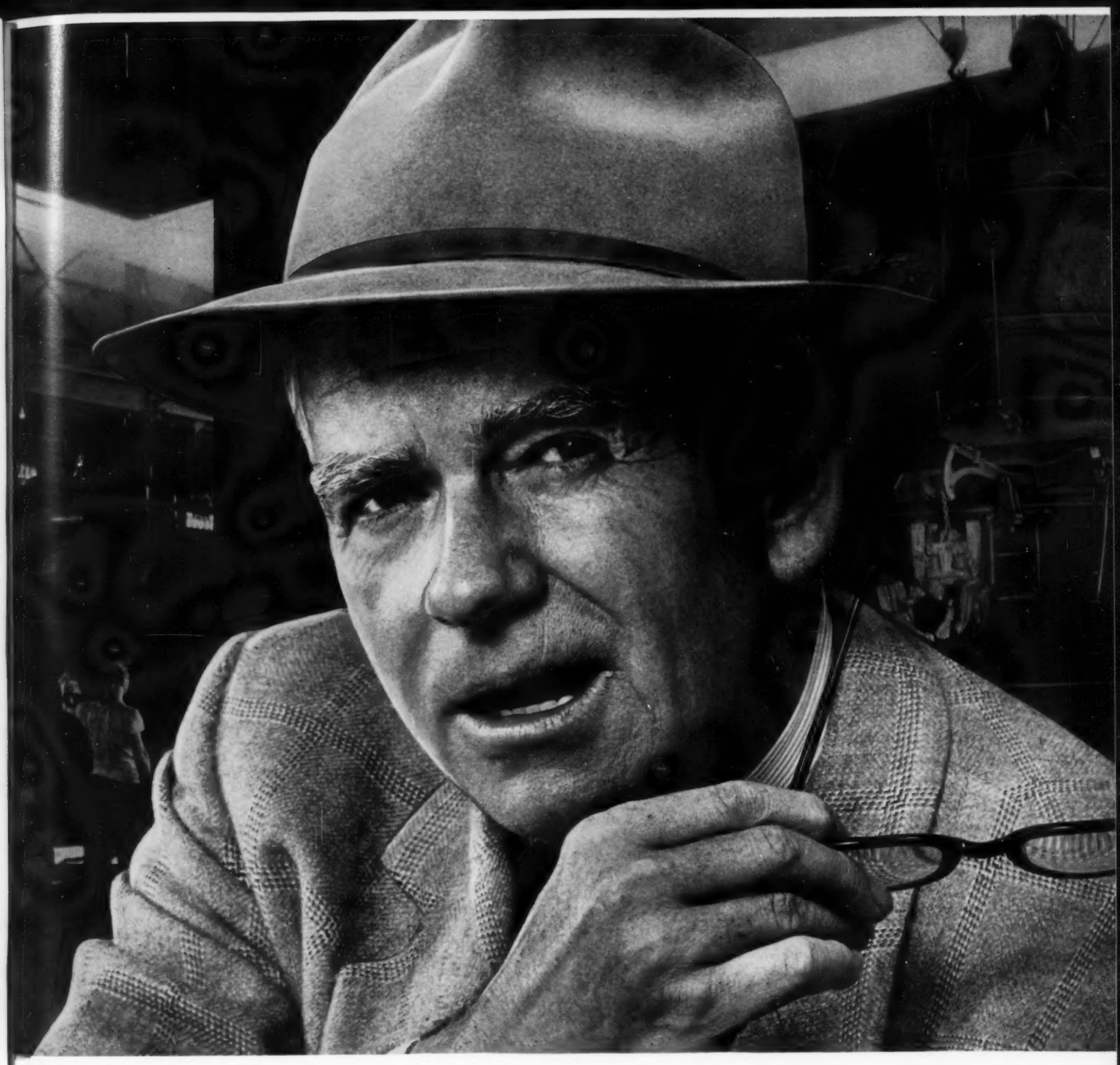
Products made of this material can be fabricated in much the same manner as cold rolled sheet without damage to the coating or effecting a color change. In most cases it can be worked on present production dies.

The liquid vinyl is applied in coatings ranging from 0.008 to 0.020 in. thick. The coating thickness may be specified in increments of 0.001 in. within this range. Color is available as specified. Hardness of the coating ranges from approximately 60 to 90 Shore A Durometer.

Steel sheets are available in gages from 18 through 28. Widths range from 24 to 52 in., in lengths from 30 to 144 in. It also can be supplied in coils.

A maximum depth of 0.005 to

Figure 1 — Vinyl-coated steel in coils is produced at United States Steel's Irvin works. Here, Robert S. Wicker, production line foreman, inspects a coil fresh from the vinyl embossing process. The new product is produced in both sheets and coils in gages ranging from 18 to 28 and in widths up to 52 in. Vinyl-coated steel production in sheets and coils involves curing and bonding of liquid plastisols to the steel in a continuous mill coating process. Prior to cooling, the coating can be embossed with any texture that can be engraved on a printing roll.



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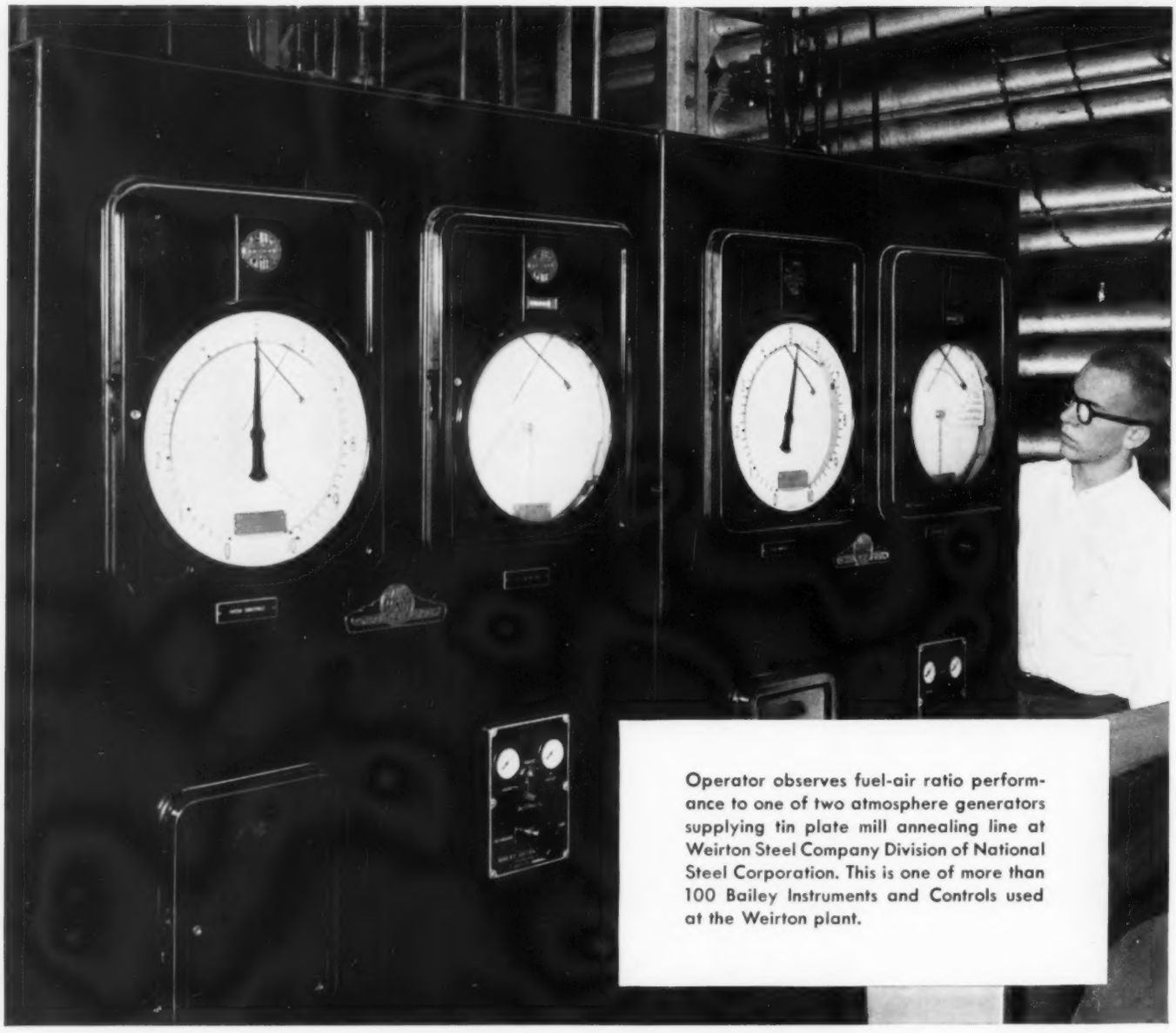

Operator observes fuel-air ratio performance to one of two atmosphere generators supplying tin plate mill annealing line at Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls used at the Weirton plant.

Bailey Atmosphere Generator Control automatically regulates total combustibles for tin plate annealing

Bailey's Atmosphere Generator Control is a completely packaged automatic control system which measures *total combustibles* in annealing.

Manual settings are made only during start-up or shutdown. Fuel-air ratio to generators is adjusted by the control system to maintain constant total combustibles despite variation in fuel quality. Response to atmosphere changes is fast, and total combustibles are accurately measured, since the Bailey Analyzer is not subject to errors due to variability of other atmosphere constituents. The Analyzer is sensitive to changes of less than ±0.02% total combustibles.

The performance of this instrument is assurance of final product quality. See your Bailey Engineer, or write the Iron and Steel Division for more information.

S112-1

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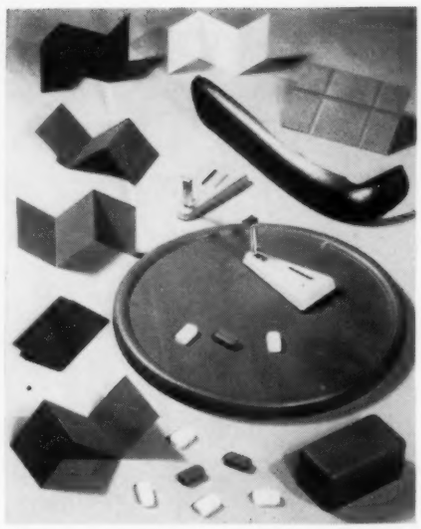


Figure 2 — The versatility of new vinyl-coated steel is shown by the variety of parts here. Fabrications ranging from flat work to deep drawing, such as the box in right foreground, are well within the workability range of the new steel.

0.006 in. can be supplied when embossing texture.

Vinyl-coated steel sheet can be sheared, slit, punched, lock seamed, stamped, drawn or roll-formed without damage to the coating or change in color. It can easily withstand elongation of 30 per cent.

Vinyl coated steel can be welded. Since vinyl itself is an insulator, current flow must be controlled from the back side.

Four basic welding techniques have been successfully applied to vinly coated steel sheets. They are: Graham stud weld; projection weld; capacitator discharge; spring loaded electrode weld; magnetic force weld. In addition, variations of these techniques have produced welds to production standards.

Vinyl-coated steel sheet can be fastened in practically as many ways as are used for fastening steel. Included in the methods are: Nut and bolt; sheet metal screws; rivets; lock seam; entrapment; spring clip; steel-to-steel adhesive; vinyl extrusion; vinyl-to-vinyl adhesive; staple; tab; and crimp.

Vinyl coated steel can withstand considerable exposure to heat without loss of color, texture or adhesion. It will stand up under 160 F on a continuous basis, under 212 F for two days. It will soften appreciably at 350 F and char at above 400 F. It will not, however, support combustion.

In many cases protection for the reverse side is not needed because the vinyl coated steel sheet is phosphatized in production. Also available for back protection as the material comes from the mill are hot dipped zinc, modified epoxy resins and temporary chemical treatments. Indoor and outdoor tests indicate that under-film corrosion is not a problem.

The tough vinyl coating provides excellent protection against wear of this type.

The product shows no staining from conventional die lubricants, alkaline cleaners, fountain pen ink, alcoholic beverages, detergents, acid cleaners, nail polish, or fruit acids.

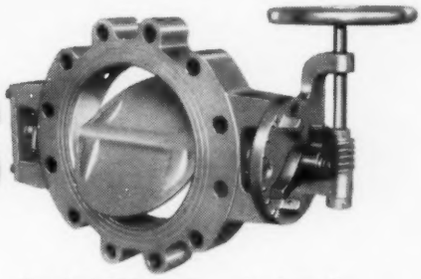
Broad fields of application for vinyl-coated steel sheets include the following: automobile interiors, appliance cabinets, architectural products, railroad car and bus interiors, office and institutional fixtures, and furniture.

Product is sold on a square foot basis and the price variations depend mainly on steel gage and on quantity. A typical price for 0.010 in. of vinyl on an 18-gage drawing quality sheet in quantities of 20,000 sq ft of a single color would be 35¢ per sq ft or approximately 2½ times the price of steel alone. The same vinyl on a 24-gage sheet would be priced at about 24¢ and on a 28-gage sheet the price would drop to 20¢. Vinyl-coated steel sheets are generally less expensive than other decorative materials such as stainless steel, anodized aluminum, wood, upholstery, porcelain enamel and solid plastics.

The most widely used decorative material with which vinyl-coated product competes is painted steel and here the economic situation is reversed; i.e., vinyl-coated steel sheets are generally significantly higher in cost than painting, for painting on a well-automated line is a relatively inexpensive process. There are a few exceptions such as in railroad car interiors where several coats of different color paints are applied manually. In such cases, the use of vinyl coated steel may actually result in a cost reduction. Fundamentally, there are two basic advantages over paint which can be demonstrated. The first is the textured appearance and warmth that are possible with vinyl coated steel. The second is the resistance to scuffing, scratching and abrasion in general of this material. ▲

ROCKWELL

"WAFER" VALVES



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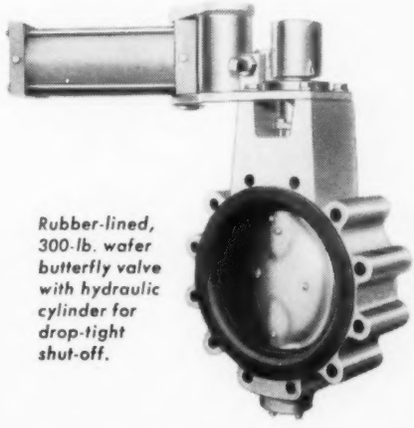

Rubber-lined, 300-lb. wafer butterfly valve with hydraulic cylinder for drop-tight shut-off.

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National Steel Announces Large Expansion Program

NATIONAL Steel Corp. will build a new steel plant in the Chicago metropolitan area. It will be located in northwestern Ind.

The new plant, part of a $300,000,000 construction program to be completed over the next three years, will also include expansion of facilities at National Steel's operations in Detroit and Weirton.

National Steel is building the Chicago plant to better provide for the increasing requirements of its many customers in this steadily growing steel market. The plant will be equipped with the most modern facilities to supply products of the highest quality. The initial installations will include facilities for the production of electrolytic tin plate, galvanized coils and sheets and hot and cold rolled sheet products.

In Detroit, at the Great Lakes Steel Corp., the program will include an increase in open hearth capacity and the addition of a modern continuous hot strip mill. This new mill and 500,000 tons of additional ingots will add to the flexibility and diversity of operation. It will also assure improved service to customers in that market area. The expansion will also enable Great Lakes to supply the immediate semi-finished steel requirements of the Chicago plant.

Work on the Detroit program will begin immediately. Great Lakes Steel's present annual ingot capacity of 3,700,000 tons will be expanded to a new total of 4,200,000 tons per year. The new mill will be an 80-in., four-high continuous hot strip mill. It will be the most powerful and fastest mill of its type in the world and will enable Great Lakes to supply the largest coils of highest quality to its customers.

At Weirton's Steubenville plant, a substantial increase in electrolytic tin plate capacity will result from the installation of two continuous annealing lines and two electrolytic tin plate lines, now under construction, which will be placed in operation within the next few months. Also included in the program for Weirton are additions to continuous annealing capacity and facilities for the increased production of cold rolled sheets. This will increase Weirton Steel's ability to meet the continuing, long-term rise in demand for the highest quality products.

Construction of the Chicago plant will begin as soon as surveys, assembly of engineering data and other preparatory work can be concluded. The plant will start with approximately 2200 employees and an annual payroll of approximately $18,000,000.

The new plant will be located on Lake Michigan in Porter County, Ind., between Gary and Michigan City. The land, consisting of about 750 acres, was purchased by National Steel Corp. in 1929 and since then has been held for use as a plant site. The Chicago plant will operate as Midwest Steel Corp., a division of National Steel Corp. President of Midwest Steel will be Albert J. Berdis who is now president of Weirton Steel and will also continue in that capacity.

Mr. Berdis is a native of Whiting, Ind., in the northwestern part of the state not far from the plant location. He is an engineering graduate of Purdue University. He gained his early steel experience at Gary and, except for a brief period in aluminum manufacture, has spent his entire career in the steel industry. A recognized expert on steel construction, Mr. Berdis has had the chief responsibility for building five separate steel plants, the largest of which was the Fairless Works of United States Steel Corp. at Morrisville, Pa. ▲

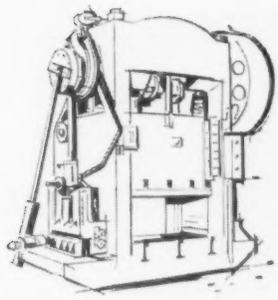
There is a constant demand for copies of "The Modern Strip Mill" published by the Association of Iron and Steel Engineers.

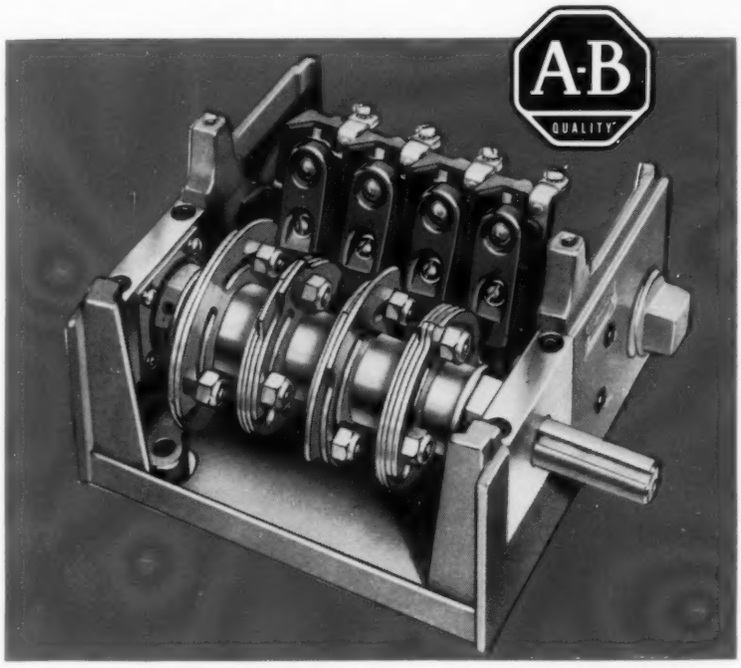
If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

ALLEN-BRADLEY HEAVY DUTY

ROTATING CAM LIMIT SWITCHES





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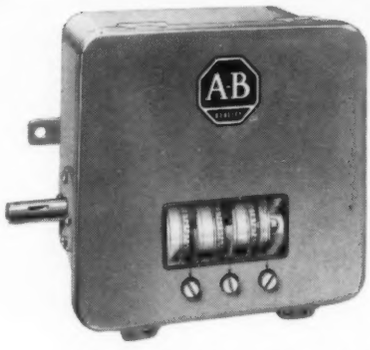
The individual contactors on the Bulletin 803 switches are independent, insulated units with staggered terminals for ready accessibility and fast wiring. Also, the double break, silver alloy contacts require no field service attention.

Get the complete story on these Allen-Bradley Bulletin 803 rotating cam limit switches—send for Publication 6084.



Automation type limit switch permits sequential adjustment of 2 to 12 independent circuits *while machinery is in motion.*

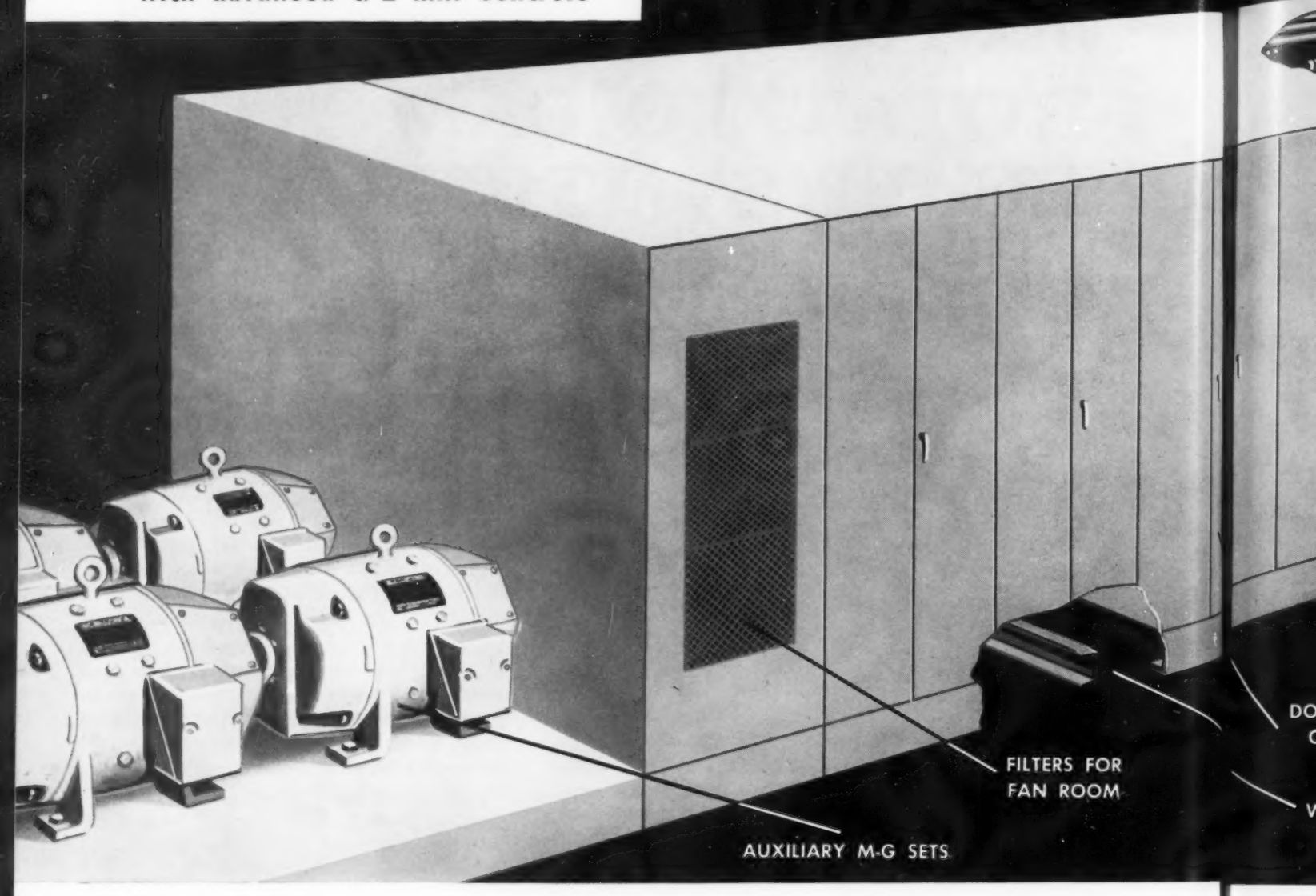
SIMPLE CAM ADJUSTMENT

Frequent changes are no problem with Bulletin 803 limit switches. Just one wrench loosens the locking nuts, leaving the other hand free to adjust the cams.

Allen-Bradley Co., 1343 S. First St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
Quality Motor Control

Greater efficiency — superior quality with advanced G-E mill controls



A NEW PRACTICE IN PROCESS-LINE CONTROL

G-E "packaged" motor-control rooms reduce

The latest innovation in modern steel-mill process-line control is General Electric's new "packaged" motor-and-control room. This novel design groups all controls and m-g sets into one compact, centralized unit. Previously, the installation expense on this equipment often matched or exceeded the actual cost of the equipment. The new G-E motor-control room design cuts installation costs as much as 40 percent!

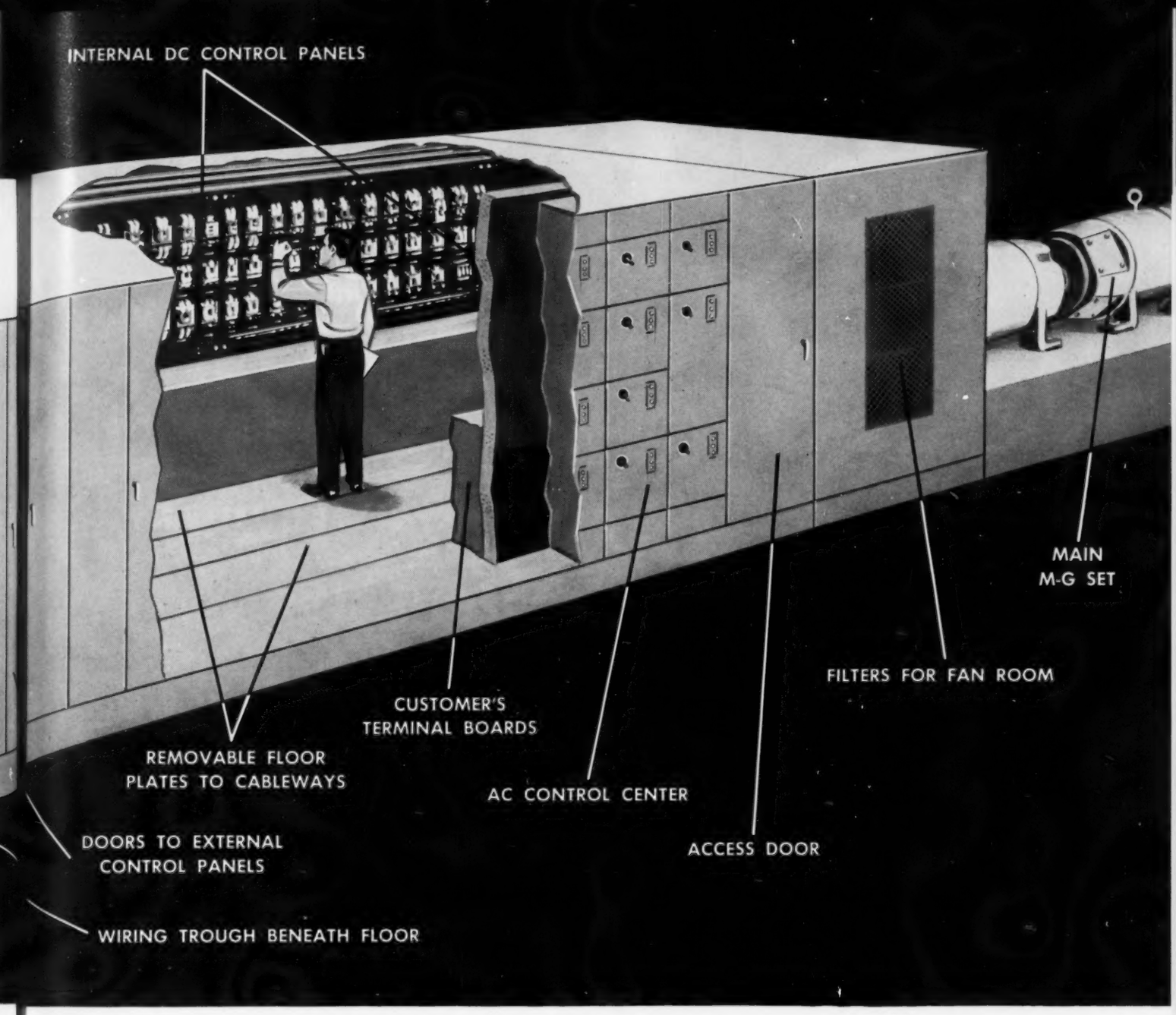
HERE'S WHY INSTALLATION COSTS ARE LOWER

Substantial savings on installation expenses can be realized through these features:

Independent control unit—The General Electric motor-control room is a completely co-ordinated, pre-assembled unit in itself, and in many cases, eliminates the need for a separate motor room. Since the motor-control room is self-contained, it may be located either near the driven equipment or in some previously unused area of the mill.

Field wiring is reduced by one-third or more—All internal connections are made and tested before the motor-control rooms are shipped. The only field wiring required is the connection of the power source and the leads to the operators' stations and the drive motors.

Construction engineering costs reduced—General Electric's grouped control concept enables the mill to know its conduit requirements much sooner. Thus, fewer, less-complex construction diagrams are needed, and actual construction can begin at an earlier date.



installation costs as much as 40 percent!

Common base minimizes installation time—This new "packaged" motor-control room, delivered on its own self-supporting platform, can be immediately set on a normal mill floor. It does not require expensive, specially-constructed foundations. With m-g sets built and shipped on a common base, the need to align them at the mill site is eliminated. In addition, regulating equipment is factory-tested prior to shipment, further expediting startup time.

For all the details on this new technique in process-line control, contact your G-E Sales Engineer today! General Electric Company, Industry Control Department, Roanoke, Virginia. 785-7

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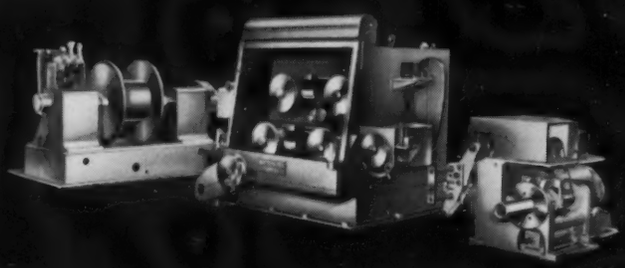
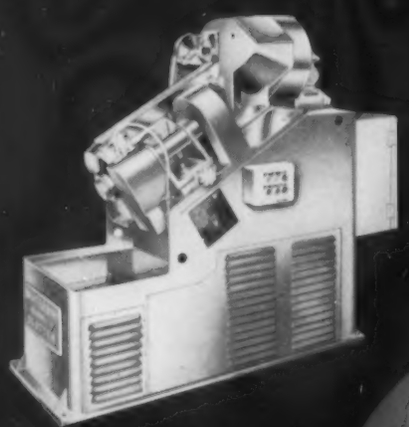
COLD HEADING MACHINERY



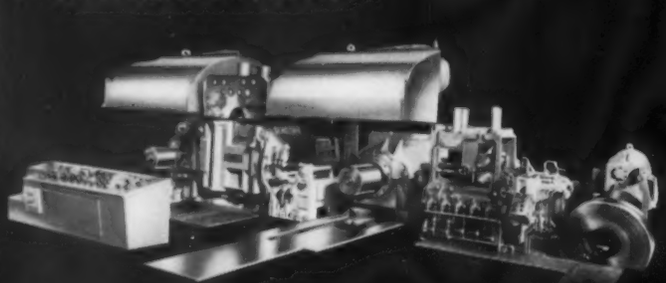


EYELET, SLITTER & WIRE MACHINERY

WATERBURY FARREL

MACHINERY BUILDERS

ROLLING MILL MACHINERY



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DIVISION OF TEXTRON INC.
Waterbury, Connecticut • U.S.A.
Sales Offices: Chicago • Cleveland • Los Angeles • Millburn, N. J.

WF-56

Date-line Diary...

February 2

△ The AISI reports that the operating rate of the steel industry for the week of February 2 is scheduled at 2,256,000 tons (79.7 per cent of capacity). This compares with 2,178,000 tons one week ago (76.9 per cent capacity) and 1,457,000 tons one year ago. Index of production for the week is 140.4.

February 3

△ Major U. S. producers increased price of copper 1¢ to 30¢ a lb. In London, spot copper eased ¼¢ per lb.

February 4

△ American Can Co. reported increase in sales in 1958 amounting to 3.1 per cent over 1957; earnings in 1958 were $2.78 a share compared with $2.51 in 1957.

February 5

△ The Labor and Commerce Depts. reported that construction outlays in January, 1959 amounted to $3,700,000,000, which was $300,000,000 under December, 1958 but $400,000,000 over January, 1958.
△ U. S. exports in 1958 totaled $16,300,000,000, which was 1/6 less than in 1957.
△ The Aluminum Assn. reported that shipments of aluminum sheet and plate in December, 1958, totaled 107,596,000 lb, compared with 97,934,000 lb in November, 1958; and total shipments in 1958 of 1,189,114,000 lb. Shipments of aluminum foil in December, 1958 totaled 17,880,053 lb, compared with 17,310,231 lb in November, 1958; shipments for the year 1958 amounted to 193,999,860 lb.

February 6

△ The Assn. of American Railroads reported that shipments in last week in January, 1959 amounted to 582,636 carloads, an increase of 32,104 cars over the same week of 1958.

February 9

△ The AISI reported that the iron and steel industry's payroll for 94.9 per cent of the industry for hourly and salaried employees totaled $325,334,615 during December, 1958 against $306,281,444 in November, 1958 and $286,081,308 in December, 1957. Average hourly payroll cost for wage earners was $3.291, compared with $3.314 in November, 1958 and $3.006 in December, 1957. Fringe benefits amounting to 33¢ per hr are not included. Total employment during December, 1958 totaled 547,902 compared with 542,464 in November, 1958; average hours worked per week in December was 37.3 compared with 36.5 in November, 1958 and 32.9 in December, 1957.
△ For the year 1958, the AISI reported that the iron and steel industry's payroll for 94.9 per cent of the industry for hourly and salaried employees, the total was $3,370,138,474, compared with $3,820,947,710 during 1957; average hourly payroll cost for wage earners in 1958 was $3.181 compared with $2.917 during 1957 (fringe benefits 33¢ per hr not included); total employment in 1958 523,451, average hours worked in 1958 35.2 compared with 37.2 hr in 1957.
△ The Bureau of Mines reported that the production of Pennsylvania anthracite for January, 1959 totaled 2,194,000 net tons compared with 2,324,000 net tons in December, 1958 and 2,197,000 in January, 1958.
△ Retail auto sales during January, 1958 amounted to 427,900 cars, 12.5 per cent below December, 1958 but 12.3 per cent over January, 1958.
△ The managements of Pittsburgh Steel Co. and Sharon Steel Corp. decided to terminate merger discussions because it did not appear probable that a satisfactory basis for merger would emerge.
△ The AISI reports that the operating rate of the steel industry for the week of February 9, is scheduled at 2,363,000 tons (83.5 per cent of capacity). This compares with 2,288,000 tons one week ago (80.8 per cent capacity) and 1,445,000 tons one year ago. Index of production for the week is 147.1.

February 11

△ The Government reported that unemployment at mid-January totaled 4,724,000.
△ The AISI reports that steel production in January, 1959 totaled 9,312,000 net tons, 600,000 tons greater than December, 1958 output, and 2,500,000 tons greater than production in January, 1958.
△ Algoma Steel Corp. reports for the fiscal year ended December 31, 1958 its net income was $11,762,618 equal to $2.05 a share compared with $14,178,296 or $2.49 a share in 1957.
△ F. W. Dodge Corp. annual review indicates that the cumulative total of contracts for future construction in the United States (excluding Alaska) in 1958 totaled $35,090,000,000, 9 per cent over the 1957 total.

February 13

△ The Commerce Dept. imposed bans on copper exports to Russia.

February 16

△ The AISI reports that the operating rate of the steel industry for the week of February 16 is scheduled at 2,439,000 tons (86.1 per cent of capacity). This compares with 2,371,000 tons one week ago (83.7 per cent capacity) and 1,373,000 tons one year ago. Index of production for the week is 151.8.
△ The Bureau of Mines reported that consumption of scrap during December, 1958 totaled 4,981,000 gross tons, pig iron 5,322,000 gross tons. This compared with 4,803,615 tons of scrap and 5,190,118 tons of pig iron in November, 1958.

February 17

△ American custom smelters increased copper price ½¢ a lb. to 30½¢. Platinum prices increased $4.90 an ounce in London, $5.00 an ounce in United States.

February 18

△ National Steel Corp. has announced a $300,000,000 construction program including a new steel finishing mill to be constructed on Lake Michigan, east of

Chicago and also a new steel strip mill and the addition of 500,000 tons of steel making capacity at the Great Lakes Steel Corp.

Δ Lukens Steel Co. reported for 1958 net sales of $98,896,681, net income $4,181,986 equal to $4.38 per share, compared with net sales of $130,473,207, net income $10,119,998 or $10.60 per share in 1957.

Δ The ARCI reports that deliveries of new freight cars in January, 1959 totaled 1940 cars compared with 2621 in December, 1958 and 7219 in January, 1958. New orders for January, 1959 amounted to 4007 compared with 3830 in December, 1958 and 401 in January, 1958. Backlog of cars on order as of February 1, 1959 amounted to 29,470 compared with 27,596 on January 1, 1959 and 55,941 February 1, 1958.

Δ The Japan Iron & Steel Federation report Japan's production of ingot steel for December 1958 at 1,094,000 metric tons, compared with November 1958 ingot production of 1,053,000 tons. Ingot production in 1958 totaled 12,115,000 metric tons.

Δ Atlantic Steel Co. reports for the year 1958 net sales totaling $22,083,434, net income $178,375, compared with sales totaling $28,115,864, net income of $268,340 in 1957.

February 19

Δ The Aluminum Assn. reported that primary aluminum production in the United States during January, 1959 was 156,708 short tons compared with 152,301 tons in December, 1958 and 139,909 tons in January, 1958.

Δ Firth Sterling Inc. reported for the year ended December 31, 1958 net sales amounting to $14,319,963, net loss amounting to $985,031, compared with sales of $26,529,442 and net income of $656,446 for the year 1957.

Δ Mesta Machine Co. reports for the year 1958 net income totaling $6,811,357, equal to $6.81 per share compared with net income amounting to $6,454,076 or $6.45 per share in 1957.

Δ The Industrial Heating Equipment Assn. reported that new orders for industrial furnaces in January, 1959 were $3,518,000 compared with the 1958 monthly average of $3,694,000 and $3,045,000 in January 1958. Total 1958 billings of $77,784,000 compare with billings of $131,827,000 total in 1957. New orders for induction heating equipment in January, 1959 amounted to $1,004,000 compared with $630,000 total for January, 1958. Total billings in 1958 were $12,034,000 compared with $17,484,000 total in 1957.

Δ Crucible Steel Co. of America reported for the quarter ended Dec. 31, 1958 net income totaling $3,021,092 equal to 80¢ per share compared with $722,717 net income equal to 19¢ a share in the fourth quarter of 1957; for the year 1958 net income amounted to $4,274,793 equal to $1.13 per share, compared with 1957 net income of $6,543,594 or $1.73 per share.

February 20

Δ Dow-Jones industrials surged above 600 for the first time in a bull market that pushed them up more than 37 per cent during the past year.

February 23

Δ The AISI reports that the operating rate of the steel industry for the week of February 23, is scheduled at 2,481,000 tons (87.6 per cent of capacity). This compares with 2,449,000 tons one week ago (86.5 per cent capacity) and 1,475,000 tons one year ago. Index of production for the week is 154.4.

Δ Shipments of iron and steel castings for December 1958 totaled 1,169,793 short tons compared with 1,106,929 tons in November, 1958 and 1,045,438 tons in December, 1957.

February 24

Δ Northwestern Steel and Wire Co. and subsidiaries report for the quarter ended January 31, 1959 net sales totaling $16,677,533, net income $1,517,192 equal to 61¢ a share compared with net sales of $10,314,968, net income of $654,902 equal to 26¢ per share for the quarter ended January 31, 1958; for the six months ended January 31, 1959 sales totaled $34,636,329, net income $2,925,068 or $1.17 per share, compared with the six months ended January 31, 1958 sales $24,041,622, net income $1,276,534, or 51¢ a share.

February 25

Δ F. W. Dodge Corp. reported that contracts for future construction in the United States (except Alaska) in January, 1959 totaled $2,319,167,000, 12 per cent over January 1958.

Δ Lead declined ½¢ to 11¢ a lb.

Δ Custom smelters moved up prices of copper ½¢ to 31¢ a lb; in London, spot copper closed at 29.93¢, ⅜¢ increase.

February 26

Δ President Eisenhower suggested that United Steelworkers limit wage demands to gains in productivity, possibly averting producers necessity to increase prices.

Δ Humble Oil & Refining Co. reduced price of crude oil 7¢ a barrel in the Texas Panhandle, Texas Co. announced a 7¢ per barrel cut in north Texas spreading the area of similar reduction in west Texas some weeks ago.

February 27

Δ Steel scrap prices declined up to $5.00 a ton in Chicago, $2.50 in Cleveland and $2.00 in Pittsburgh.

Δ The Securities and Exchange Commission report a drop of $550,000,000 in new securities offerings by manufacturing firms in the last quarter of 1958; for the year 1958 offerings of new securities by corporations, excluding investment companies, amounted to $11,600,000,000, $1,300,000,000 below the 1957 total.

Δ The AISC reported that bookings of fabricated steel in January, 1959 totaled 235,784 tons, shipments in January, 1959 amounted to 224,260 tons, compared with January 1958 with 162,158 tons booked, 316,742 tons shipped. Backlog of future work amounted to 1,794,430 tons.

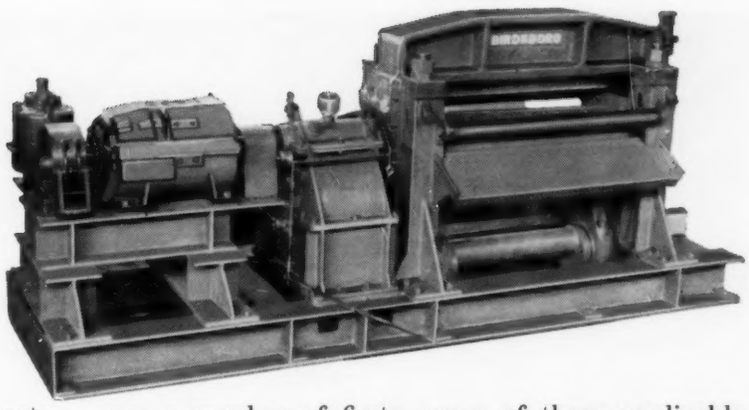
Δ Auto dealers report new cars sales in the second third of February, 1959 averaged 16,300 cars daily, an increase of 34 per cent over the like 1958 period; retail volume is running at an annual rate of over 5,000,000 U. S.-built cars.

Δ Government figures showed that construction spending for January and February, 1959 totaled $5,100,000,000, a gain of 9 per cent over the same period in 1958.

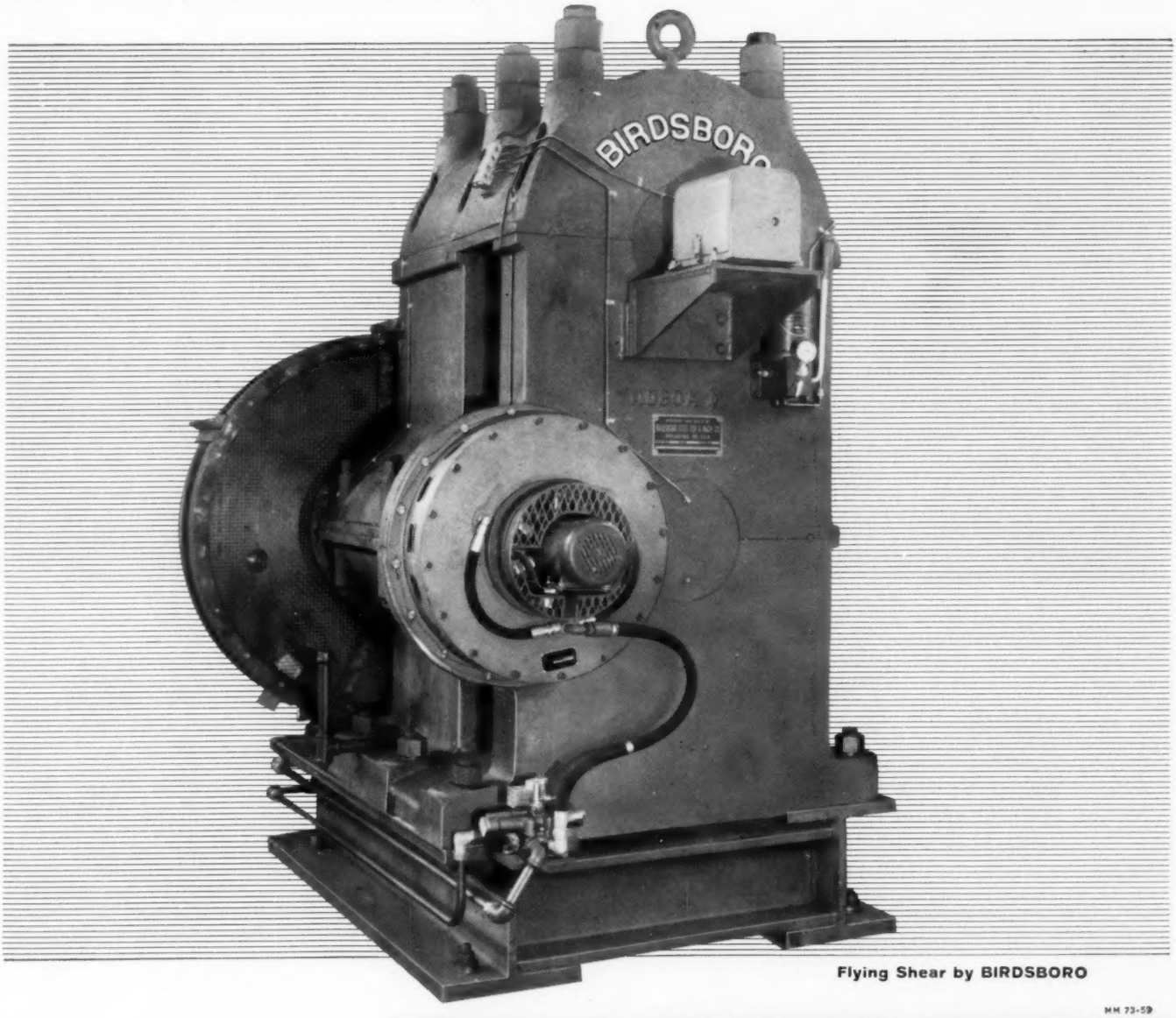
Δ Canadian steel union offers to link wages to labor productivity and called on Canada's government for an immediate investigation of steel prices, describing this move as part of an anti-inflation program to be carried out with the co-operation of business and government.

BIRDSBORO

Customized Shear Designs pay off in higher productivity



• Like any other key piece of mill equipment, shears have been given a lot of BIRDSBORO's attention in recent years. As a result, many innovations are available to the mill operator that can eliminate former problems and provide a finer product at a lower cost. BIRDSBORO's shear case history book is a full one. In it you can see a number of firsts, some of them applicable to your operation. The BIRDSBORO representative can help apply creative engineering to your mill. *Sales Department, Engineering Department and Plant:* Birdsboro, Pa., *District Office:* Pittsburgh, Pa.



Flying Shear by BIRDSBORO

HM 73-59

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STEEL FOUNDRY AND MACHINE CO.

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • Weldments "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel

Overhead cranes . . . ingot buggies . . . transfer cars . . . electric mules . . . unloaders . . . quench cars—in fact, virtually every type of traveling mill equipment—can be operated by a FEMCO Remote Control System.

These systems cover a wide range of operations: simple remote control of a visible process; remote control and position indication of a hidden process; automatic remote control and position indication of a repetitive process.

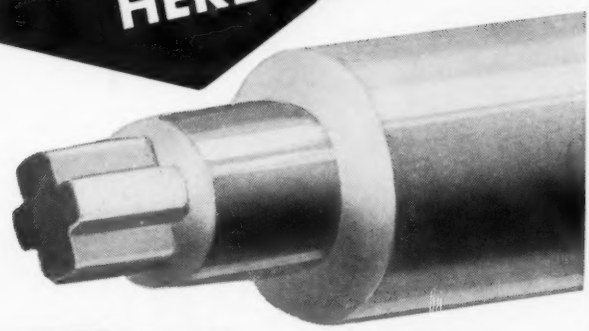
Control and indication signals are transmitted over existing power circuits by utilizing carrier frequencies. As many as eight pieces of equipment on a single power circuit may be controlled in this way, simply by using different frequencies.

Control consoles may be in any location desired, either individually or grouped together. Substations may be provided to permit control from various points, or the control station may be mounted on wheels and moved from point to point as needed.

For full information on Femco Remote Control Systems, write to FEMCO, INC., IRWIN, PA. Details about the specific applications in which you are interested will be helpful.

Femco COMMUNICATION AND CONTROL SYSTEMS FOR MODERN INDUSTRY

SAVE WEAR HERE



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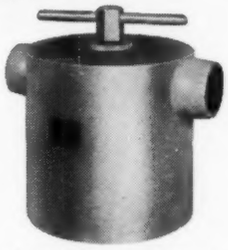
Save wear on roll neck bearings and other vital contact points by extracting ferrous grit—rust, steel particles worn off equipment, core sand, etc.—from lines circulating lubricating oil in heavy mill equipment.



Model PQ-6 for 3" pipe line available with screwed or flanged connections. Other sizes from $^3/_8$" to 8".

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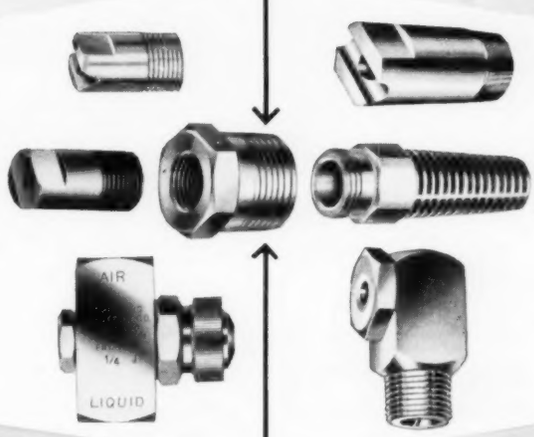
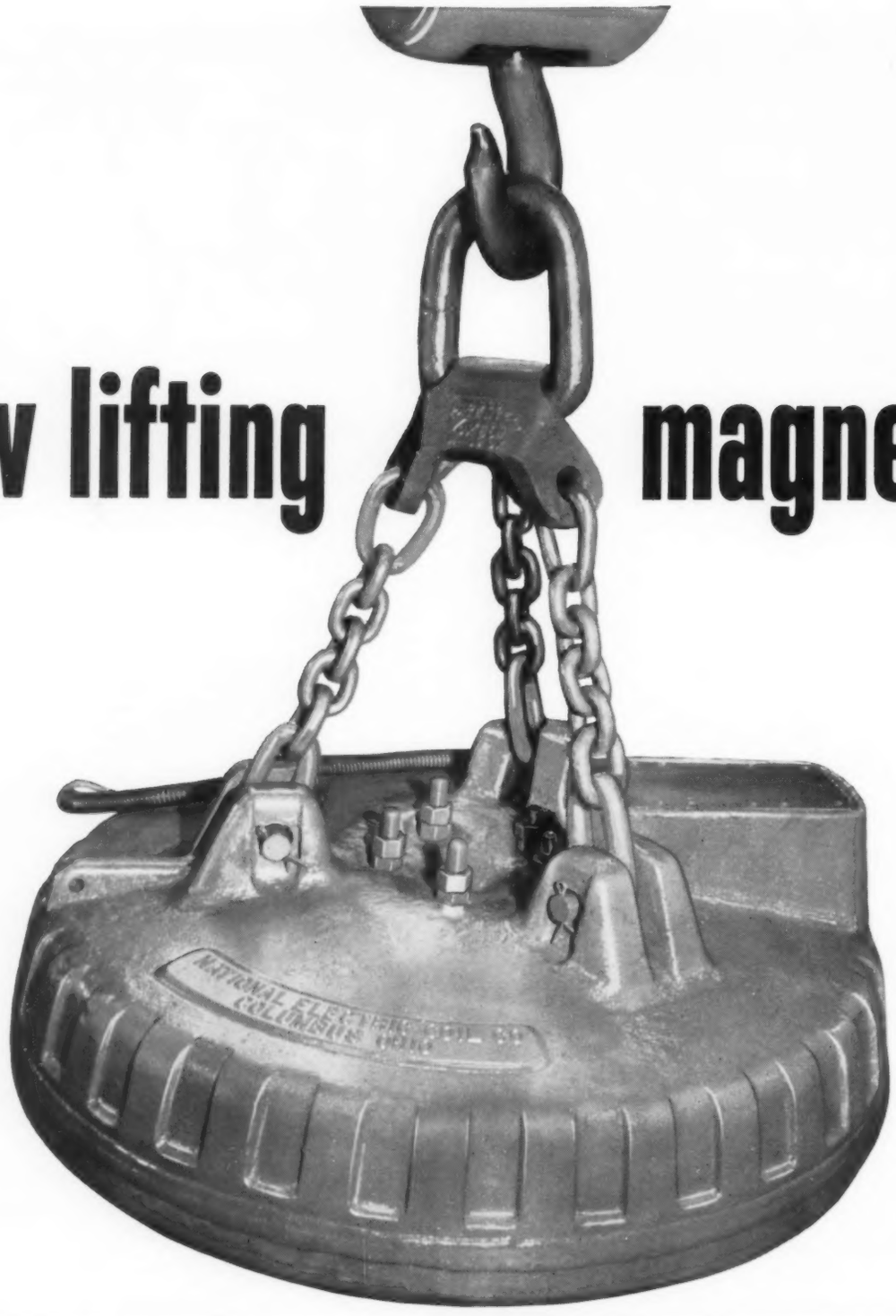
Whatever the application you will find Spraying Systems Spray Nozzles provide noticeable improvement in spraying operations . . . and often materially lower cost. Proved by performance. Supplied in a complete choice of types and capacities for selection of spray characteristics exactly as needed. Your inquiry is cordially invited.



SPRAYING SYSTEMS CO.
3262 Randolph Street • Bellwood, Illinois

For complete information write for Catalog 24 and special data sheet folder "Steel Mill Applications".

New lifting magnets



SPECIFICATIONS	55″	65″
Voltage	230 D.C.	230 D.C.
Amperes (cold)	55	85
Amperes (hot)	48	74
Weight	7500 lbs.	10,600 lbs.
Duty cycle	Intermittent	Intermittent
Field strength at hot amperage:		
1. At a point 7″ below center of inner shoe—Gauss	1700	1900
2. At a point 7″ below center of outer shoe—Gauss	425	525

AVERAGE HOT LIFTING CAPACITY	55″ POUNDS	65″ POUNDS
Skull cracker balls	23000	38000
Slabs, billets	53000	68000
Machine cast pig	3000	3700
No. 1 heavy melting steel scrap	3200	3500
No. 2 melting steel	2000	3500
No. 1 machinery scrap (cast iron)	1700	2400
Cast iron borings	1700	2400
Steel turnings	1000	1200

Rebuilding-redesigning all makes and types of magnets has been one of our longtime specialties. And it still is. But our customers made it plain that they wanted a better magnet in the first place. A magnet that was watertight. Burnout-resistant. Longer lasting.

Logically, we're now using our broad magnet experience to make the kind of magnet our customers want. Among other things, National is now a *lifting magnet manufacturer*, and in full-scale production.

Write us for complete information and prices, or call your nearby National field engineer.

from National Electric Coil!

IMPORTANT ADVANTAGES:

- ***Burnout-resistant!***
- ***Watertight!***
- ***Outstanding factory service!***

High resistance to coil burnout

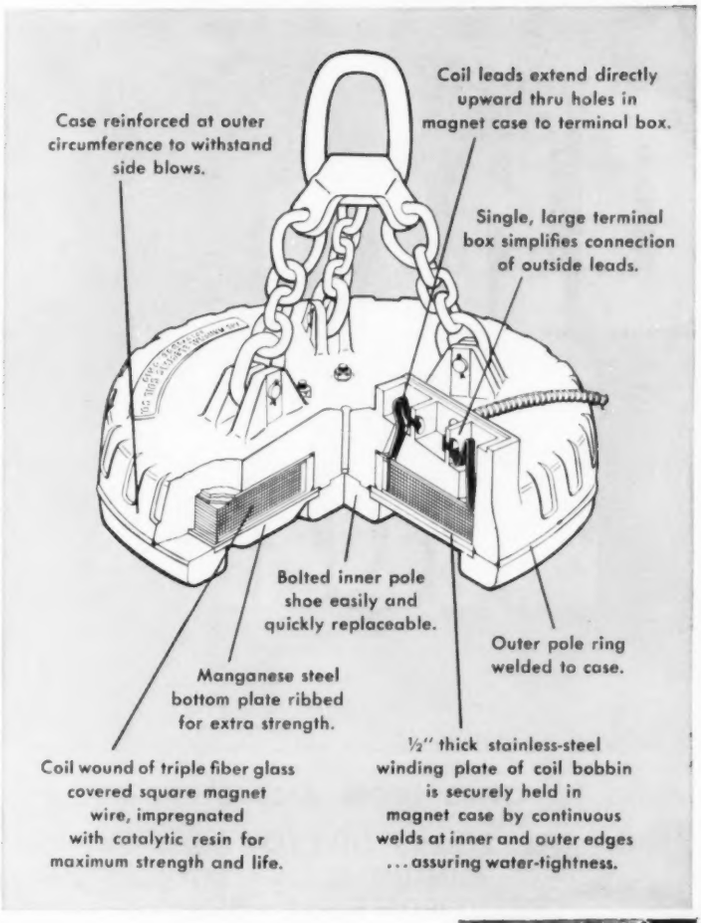
Overheating does it, and it's the chief cause of magnet failure. We've made a cooler-running magnet coil with square magnet wire triple-covered with Fiberglas . . . impregnated with high-temperature resin, then cured into a monolithic structure of great mechanical strength—able to withstand severe heat cycling and shock. Void-free insulation rapidly transfers heat to the magnet iron.

Watertight design

Moisture is right behind overheating as a trouble-maker, so we wind the coil on a ½" stainless steel plate, and anchor the plate to the magnet case with continuous welds at inner and outer edges. The seal is 100% watertight. Internal condensation is prevented by vacuum-drying the case and filling all voids with asphaltum—which in turn water-proofs the coil and leads.

Outstanding factory service

National backs up your purchase with magnet repair facilities and craftsmen second to none. Whenever the need arises, you can depend on National for economical service, prompt delivery, quality work throughout.


Coil leads extend directly upward thru holes in magnet case to terminal box.
Case reinforced at outer circumference to withstand side blows.
Single, large terminal box simplifies connection of outside leads.
Bolted inner pole shoe easily and quickly replaceable.
Outer pole ring welded to case.
Manganese steel bottom plate ribbed for extra strength.
Coil wound of triple fiber glass covered square magnet wire, impregnated with catalytic resin for maximum strength and life.
½" thick stainless-steel winding plate of coil bobbin is securely held in magnet case by continuous welds at inner and outer edges . . . assuring water-tightness.

McGRAW EDISON

National Electric Coil

DIVISION OF McGRAW-EDISON COMPANY
COLUMBUS 16, OHIO

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shaping metal for all Industry

OHIO IRON AND STEEL ROLLS

CARBON STEEL ROLLS • OHIOLOY ROLLS • OHIOLOY "K" ROLLS
FLINTUFF ROLLS • DOUBLE-POUR ROLLS
CHILLED IRON ROLLS • DENSO IRON ROLLS
NICKEL GRAIN ROLLS • SPECIAL IRON ROLLS
NIOLOY ROLLS • FORGED STEEL ROLLS

The Ohio Steel Foundry Co.

LIMA, OHIO

LIMA... Virtually at the center of the steel industry

PLANTS AT LIMA AND SPRINGFIELD, OHIO

Industry News...

J&L DEVELOPS PLASTIC PIPE TO CARRY SLURRY

△ A serious corrosion problem has been solved by using 350 ft of a new kind of steel-jacketed plastic pipe to carry a slurry of powdered coal and water at the Pittsburgh Works of Jones & Laughlin Steel Corp.

A highly corrosive substance, the coal slurry presented a handling problem to J&L engineers when they designed a system to collect coal dust that was being vented into the atmosphere. The dust came from three pulverizers used to crush coal, needed to fire the boilers in the Works' Blast Furnace Department.

As part of J&L's smoke abatement and waste treatment program at its Pittsburgh Works, three gas scrubbers were installed on the coal pulverizer vent pipes to collect the dust.

Next, the engineers wanted to pump the collected dust in slurry form to a point 350 ft from the pulverizers where it would be mixed with ore dust collected from the blast furnaces. This mixture is used later in the sintering process to produce a high-grade charge for the blast furnaces.

J&L engineers planning the new installation realized that the high sulphur content of the coal slurry would create a severe corrosion problem if carried in regular unlined line pipe. Other types of pipe were considered, and while these were under study, a new kind of pipe was developed by J&L's Product Development Division and Electrieweld Tube Division.

The new pipe is called Jal-Jacket.

Positive seal at the joints and quick make-up are provided by the use of grooved couplings which lock into mill-rolled grooves. Pipe ends as well as inside surfaces are completely protected with the PVC lining.

It consists of a rigid polyvinyl chloride lining encased in a steel jacket. Its plastic lining gives it resistance to a broad range of corrosive fluids. The steel jacket gives it great strength, enabling it to carry fluids or gases under higher pressures.

Because of these characteristics, the new pipe was selected to carry the coal slurry. For more than six months, a three-inch Jal-Jacket line has been conducting the coal slurry over the 350 ft from the pulverizers to the collecting point.

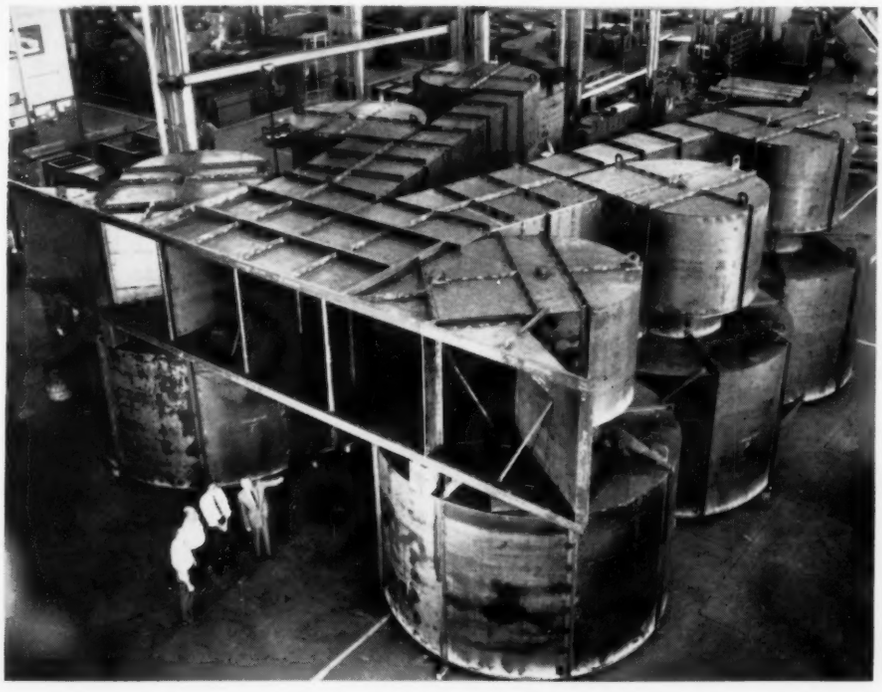
Not a trace of corrosion has developed. During this same period, say J&L engineers, unlined line pipe would have broken down under corrosion.

Mill-rolled grooves at the pipe ends enable pipe lengths to be joined by grooved couplings. These lock into place, assuring a positive seal at the joints. This system of joining permits an installation to be dismantled and reassembled without damage to the lining.

The pipe is so designed that the pipe-ends as well as the inside surfaces are completely protected with the polyvinyl chloride or PVC lining. The smooth surface of the PVC results in a lower friction coefficient and higher flow efficiency

COLLECTING DUST AT INDIANA HARBOR

This giant six-in-one American-standard dust collector was recently delivered to the Arthur G. McKee Co. for installation at the Youngstown Sheet & Tube Co.'s Indiana Harbor Works. The unit is actually six type "D" cyclone collectors in one. It has been so designed to meet existing space requirements and to tie in with other equipment in the dust collection system. It is rated to handle a gas volume of 375,000 cfm at 300 F. Used between the sintering machine manifold and an electrostatic collector, the unit includes a 42-ft wide outlet designed to fit the electrostatic collector inlet. The outlet is sectionalized to provide a separate discharge opening for each of the six individual collectors for more uniform, hence better, gas and dust distribution to the electrostatic unit.



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that may often permit the use of a smaller diameter pipe than would normally be required.

The electric-resistance-welded steel jacket encasing the PVC lining overcomes the pressure limitations common to most plastic pipe. Working pressures of 1000 pounds psi at 150F can be attained with Jal-Jacket.

MESTA AWARDED INLAND TEMPER MILL CONTRACT

Δ A contract for the design and manufacture of a 54-in. twin stand temper pass mill and auxiliary equipment for the Indiana Harbor Works of Inland Steel Co., has been awarded to Mesta Machine Co.

Designed to skin pass strip up to 48-in. wide at a maximum speed of 7000 fpm the equipment will include two 54-in. temper mill stands with entry and delivery tension devices, cobble knife, and automatic roll polishers; feed reel with double overhung mandrels and elevating coil cradle; tension reel of the automatic shifting type to provide straight sided coils, with elevating stripper and belt wrapper; oil and grease lubricating systems; and an exhaust system.

To maintain an ample number of coils ready for the mill, and permit full utilization of its design speed, Mesta will supply auxiliary coil handling equipment, including a coil positioner to receive the coil and rotate it into position for shearing off the scrap end; a crop shear; and a coil lowering unit to place the coil on the entry coil conveyor, which will be capable of moving four coils in elevated saddles to the feed reel. A delivery conveyor approximately 58 ft long, capable of handling seven finished coils, and incorporating a mechanical coil weighing device, will also be included.

MERGER OF ENGINEERING SOCIETIES IS ANNOUNCED

Δ On January 29, the merger of the American Society of Heating and Air-Conditioning Engineers with The American Society of Refrigerating Engineers was completed. The new Society is the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

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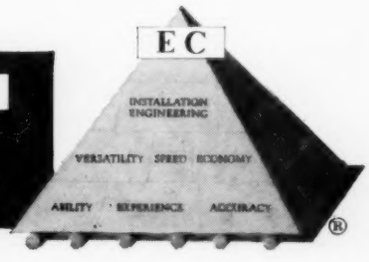

The consolidated Society will have a membership of more than 18,000.

PENN STATE SUMMER PROCEEDINGS AVAILABLE

△ Proceedings are now available for two short courses conducted at Penn State during the summer of 1958 dealing with Materials Engineering Design for High Temperatures and Mechanical Properties of Materials. These proceedings cover recent developments in two important fields of mechanics and materials by national authorities in the field.

If you are interested in copies of these proceedings please write to: J. Marin, Dept. of Engineering Mechanics, The Pennsylvania State University, University Park, Pa.

GAS TURBINE FOR MILL FINDS NEW APPLICATION

△ A gas turbine for Mexico's largest steel mill is now being tested by the Westinghouse Electric Corp.'s steam division in Lester, Pa. The 8500-kw unit will be installed at Monclava near Monterrey to generate electrical power for use in the mill of Altos Hornos de Mexico.

Exhaust gas from the turbine will pass through a boiler which will supply steam to drive a steam-turbine air blower for a blast furnace. This new gas turbine application will result in a high overall plant efficiency for the Mexican company.

REFRACTORIES FIRMS ANNOUNCE MERGER TALKS

△ Kaiser Aluminum & Chemical Corp. and Mexico Refractories Co. have entered into negotiations which may lead to a possible merger for the purpose of combining their respective refractories business.

The Kaiser Chemicals Division of Kaiser Aluminum & Chemical Corp. is a major supplier of basic (magnesia) refractories used for high temperature applications. Mexico Refractories, not at present in the basic refractories field, is a major supplier to industrial users of clay, silica and alumina refractories and a wide variety of special refractory products. The product lines of the two organizations would supplement one another.

J&L AWARDS CONTRACT FOR COKE OVEN BATTERY

△ The contract has been awarded for a new $6,000,000 battery of by-product coke ovens at the Pittsburgh Works of Jones & Laughlin Steel Corp., it was announced by A. A. Archibald, J&L's vice president—engineering and plant.

The new battery, which will consist of 59 smokeless coke ovens with a rated monthly capacity of 30,000 tons of coke, is the second planned for J&L's Pittsburgh Works in recent months. The new facilities are part of a program to modernize coke ovens throughout J&L's steelmaking operations, Mr. Archibald said.

J&L started construction of a similar 59-oven battery in November, 1958. That project is scheduled for completion late in 1959, and construction on the new battery will be started shortly thereafter.

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Completion of the two phases of the program will enlarge the Pittsburgh Works By-Product Department to six batteries with a total of 437 ovens and a monthly rated capacity of approximately 143,000 tons of coke, Mr. Archibald said. This is a monthly increase of almost 46,000 tons of coke, he added.

The new battery will be constructed on the site of an older 60-oven battery, which because of its obsolescence, can only be operated at a maximum rate of approximately 12,000 tons of coke per month.

The Wilputte Coke Oven Division, subsidiary of Allied Chemical Corp., has been awarded the contract for the new battery. Wilputte also is the contractor for the 59-oven battery currently under construction.

Both batteries will be similar, Mr. Archibald said, in that they will feature the modern Wilputte recovery-type ovens and a rotating table charging car which permits rapid chargings without smoke emersion. Coal for the ovens will be charged mechanically rather than by gravity for a more uniform distribution in the ovens.

Additional coal bin capacity and flushing liquor facilities for gas scrubbing and removal of tar and other by-products also will be installed with the new battery.

The installation also will include the Wilputte pusher machine which has a one-position stop for door removal and coke pushing. In older-type pusher machines, it was necessary to change position several times for these operations.

FORD STEEL DIVISION TO MODERNIZE FACILITIES

△ Ford Motor Co. has announced a quality improvement and modernization program costing more than $35,000,000 for its steelmaking facilities at the Rouge plant in Dearborn, Mich.

Irving A. Duffy, vice president—body group, said the multi-million-dollar project will get under way as soon as engineering plans are completed. Work will continue to mid-1962.

"This program," Mr. Duffy said, "is in line with Ford's policy of keeping its manufacturing divisions provided with facilities to produce products of quality representative of the highest technological attainments of the industry.

"When this program is completed our Steel Division facilities and processes will be among the most modern for melting, rolling and finishing highest quality automotive steels."

Ford first began making steel in 1923. The company's 1959 annual ingot capacity is listed as 1,898,600 tons—the 13th largest in the United States.

Ford recently has produced about 50 per cent of company steel requirements. Mr. Duffy stated that, despite the modernization program, Ford will continue to rely on independent suppliers for about half of its steel needs.

In listing details of the modernization program, William J. Reilly, general manager of the Steel Division, said a 75,000-sq-ft building extension would be added to the cold rolling mill and that new facilities and operational changes

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would extend through all the steelmaking processes.

Specific items in the program include:

(1) Blast furnace capacity to be increased by improving furnace stoves in order to increase blast temperatures. Higher quality refractory linings will be installed inside the furnaces.

(2) Open hearth furnaces will be renovated to employ greater amounts of oxygen during the steelmaking operation. Quality improvements will result from better furnace controls and improved mold-conditioning facilities.

(3) A new bank of four soaking pits will be added to the present 20 in the rolling mill.

(4) A fourth slab reheating furnace will be installed in the hot strip mill. Finishing stands of this mill will be repowered with larger motors to improve product quality.

(5) A complete new four-stand tandem cold rolling mill will be installed.

(6) Additional annealing facilities will be housed in the building addition.

(7) New recoiler and welder near the annealing operation and modern welding equipment for one acid-pickling line will improve yield and quality.

(8) A new shipping and storage facility will be made available by equipment rearrangements.

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KEOKUK AND VANADIUM DISCUSS MERGER PLAN

△ Arrangements for the merger of Keokuk Electro-Metals Co. into Vandium Corp. of America have been under discussion, it was disclosed in a joint announcement by W. C. Keeley, president of Vanadium, and G. L. Weissenburger, president of Keokuk. The terms which, according to present plans, will involve the exchange of stock, will be subject to approval of stockholders of both companies.

Vanadium Corp. of America mines vanadium, chromium, uranium and manganese ores, and it processes ferroalloys of chromium, vanadium, manganese, titanium, silicon and columbium at its plants which are located in New York, Ohio and West Virginia. The firm mines and mills uranium-vanadium ores in the Colorado Plateau area. Its chromium and manganese mines are located in Southern and Northern Rhodesia.

Keokuk Electro-Metals Co., at its plant at Keokuk, Iowa, is the world's largest producer of electric furnace silvery pig iron, principally sold to iron foundries, and it also produces other alloys. At its Wenatchee, Wash., plant it produces silicon metal used chiefly in the alloying of aluminum. Keokuk will continue to produce and distribute its products under its own trade names. It does not engage in mining.

TO MOVE GENERAL SALES OFFICE TO OAKLAND

△ Kaiser Aluminum & Chemical Corp. has announced that it plans to move its general sales offices from Chicago, Ill., to Oakland, Calif., within the next few months.

In anticipation of the forthcoming move, the company, more than a year and a half ago, established six regional sales managers in close proximity to major market centers with broad authority to

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TO SPECIFICATION...

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

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make decisions involving customer service. These regional managers direct the efforts of 18 district and 35 branch sales offices located in important industrial cities.

Kaiser Aluminum plans to retain in Chicago its present regional and district sales headquarters, and to maintain an executive office there. In order to continue to effectively serve the important Midwestern and Eastern markets some personnel whose activity is primarily concerned with technical and field service will also remain in Chicago.

The move to Kaiser Center in Oakland will be accomplished in planned stages, with completion scheduled for about September 1.

J&L ENTERS MARKET FOR ELECTRICAL STEEL

Δ Jones & Laughlin Steel Corp. is entering the market for electrical steels for the first time, according to an announcement made by Avery C. Adams, chairman and president. The company is soliciting orders for a series of new carbon electrical steels made in the company's new basic oxygen furnaces. It is believed that these steels, to be marketed under the trade name "Jalox," will be the first electrical steels marketed in the U. S. made by this process.

The company began operations with the new type refining furnaces in October of 1957, and started a program of research and development work on magnetic steels for the electrical field made by this process shortly thereafter, according to Mr. Adams.

The move by J&L marks another stride for the company in the invasion of specialty steel markets. In the past three years the company has gone into the stainless and precision strip steel businesses, and has added to its existing product lines in a number of other fields.

Mr. Adams stated that steel companies who have been producing electrical steels have done an outstanding job of anitcipating the requirements for the transformer manufacturers. "It is our intent," he said, "to do an equally good job for the makers of motors."

The entry into the electrical steel business will give J&L another tie to the $20 billion-a-year electrical manufacturing industry.

Steel made in the basic oxygen furnaces is especially suitable for electrical steels, according to Mr. Adams. Undesirable inclusions occurring from time to time in electrical steel made by normal processing have a measurably harmful effect on the performance of the steel. The low sulphur and nitrogen contents of steel made by the oxygen process are especially advantageous in the making of electrical steel.

The company indicated that its entry into this field will consist of three grades of nonsilicon bearing motor grades of electrical sheets. This will follow the trend already well established in this market of shifting to carbon steels for many motor lamination applications. Two of the new J&L grades will compete with existing materials now available in the market, while the third will be a greatly improved carbon steel promising the full benefits of magnetic performance inherent in the use of steel made in basic oxygen furnaces. All will be produced at the J&L Aliquippa mill.

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AIR DUMP
CARS

New Magor Air Dump Cars are designed to take the toughest punishment—and keep going! Rugged end construction of double plate across load carrying members and tapered end design shrug off abuse. Alloy steel in structural members, wearing parts gives added strength where it's needed most!

Except for the rubber coupling hose at the ends of the car, the entire air supply system is made of extra heavyweight black steel pipe, immune to damage by heat of lading!

These are really rough and ready cars, designed specifically for the job—built to last! Every feature (and we've mentioned only a few) is made to take the tremendous beating that goes with Steel Plant operation.

MAGOR

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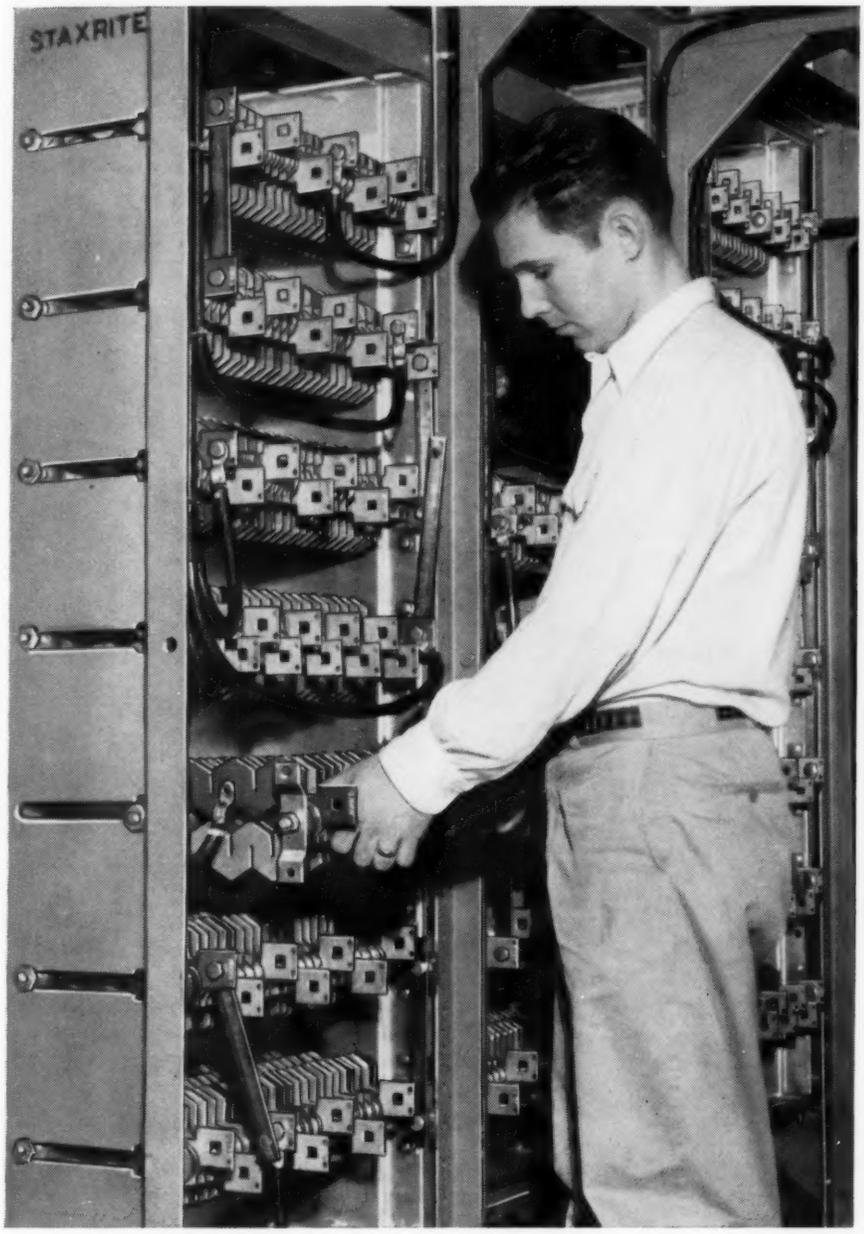
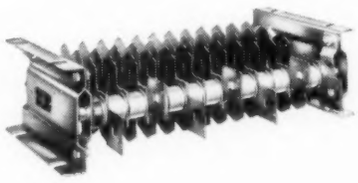


Here is the very latest word in Mill Duty resistors . . . Cutler-Hammer's "draw-out" designed non-breakable mill duty resistors and Staxrite®, the multiple resistor mounting frame. Together these two units become a solid free-standing resistor bank that can be "custom-tailored" to meet your specific needs. Staxrite resistor frames, available in graduated sizes, will accommodate up to nine non-breakable resistor units. Add to this the optional feature of a terminal board and grid-to-terminal wiring and your resistor bank is ready for rapid installation. No more time-consuming box-to-box mounting. Costly on-the-job wiring is cut to a bare minimum. A Staxrite resistor bank saves valuable space too . . . it only requires the floor area of a single resistor box.

Notice how easily the "draw-out" designed resistor units slide in and out of position; this is a Cutler-Hammer exclusive. Each resistor unit is completely independent, and can be serviced or replaced by a spare unit without disturbing end frames, adjacent resistor units, or mounting members. "Draw-out" design will cut your "down-time" during maintenance and alterations. Enclosed resistor banks also available . . . added safety for your men and protection for the resistors. For further information, write Dept. F232, Cutler-Hammer Inc., Milwaukee 1, Wis.

Cutler-Hammer's Non-breakable Mill Duty Resistors are the choice of Mill engineers everywhere



These extra rugged resistors were designed specifically for mill and crane applications where service is severe. Cutler-Hammer 11011 Mill Duty resistors are available in three standard widths and can be mounted independently or in a Staxrite mounting frame. Check these other important features of design and construction.

- Stamped chrome-steel grids
- Shock-proof
- Vibration-proof
- Corrosion-resistant
- Welded grid joints
- No pressure dependent grid contacts
- Staggered, projected terminals
- Welded grid-to-terminal joints
- Heavy duty mica insulators

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8 good reasons why you should use these ROLLER GUIDES in your bar or wire rod mill

Nos. 125 and 155 roller guides fitted in a 27 1/2 in. (700 mm.) diameter, three-high stand for rolling 2 3/4, 3 3/16, 3 9/16, 4, 4 3/8 and 4 7/8 in. (70, 80, 90, 100, 110 and 124 mm.).

1 The entry friction guides are rigidly clamped into the guide box. They are intended to lead the oval to the groove in the roller, to protect the rollers against overloading, and to straighten bent rods.
The groove in the entry guides is made about 1/8" wider than the oval.

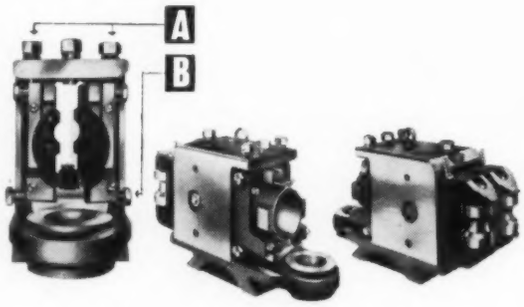
2 The rollers are mounted on leaf springs, which can be adjusted by means of the screws "B", and hold the oval steadily even if there should be some slight variation in the thickness of the oval.

3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be thick, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.



7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

8 The roller guide may be used not only for leader and drawing oval passes but also for edging flats as well as for rolling squares, hexagons, octagons and various other sections, for instance in reduction passes for hexagon. It is suitable for all types of rolling mill. An important advantage is that the roller guide enables repeaters to be used in rolling plump leader-ovals.

PS *Practically speaking, every bar and wire rod mill in Scandinavia uses roller guides of our design.*

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FIRM ANNOUNCES NEW METAL COATING SYSTEM

△ A new metal coating system that marks a major advance in bonding vinyl plastic to steel was announced by B. F. Goodrich Industrial Products Co., division of The B. F. Goodrich Co.

The system features a new adhesive which keeps its stubborn grip beyond the point where all other vinyl-to-metal adhesives fail.

According to Clyde O. DeLong, president of the Industrial Products Co., sheet steel bonded to vinyl with the new A-978-B cement can be stretched 35 per cent without weakening the bond or damaging the vinyl coating.

"No other vinyl-to-metal adhesive has passed torture tests devised to evaluate the new material," Mr. DeLong said. "These tests—including boiling in water for 30 minutes, exposure to 200 F for seven days and humid storage at 160 F for 1000 hours—prove that the A-978-B bo d remains as strong after stretchin as before."

The material will be produced in the company's new adhesives plant in Akron, Ohio.

Meetings

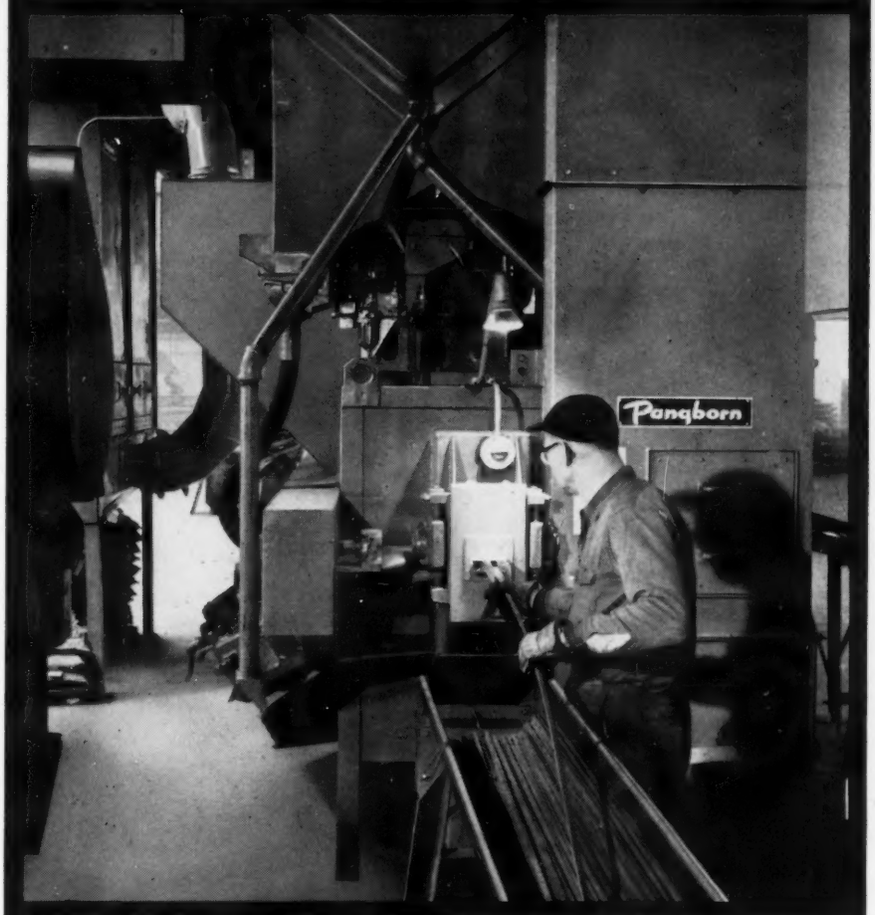
△ The 42nd Conference of the National Open Hearth Steel Committee held jointly with the Blast Furnace. Coke Oven, and Raw Materials Conference, of the Iron and Steel Division, The Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers, will be held April 6–8, in the Sheraton-Jefferson Hotel, St. Louis Mo.

△ The annual meeting of the Air Pollution Control Association will be held June 22–26, at the Hotel Statler, Los Angeles, Calif. This meeting will include technical sessions and exhibits.

△ The Galvanizers Committee of the steel industry, sponsored by the American Zinc Institute, will hold its 40th meeting April 23–24, at the Drake Hotel, Chicago, Ill.

△ The 14th Annual Meeting and Lubrication Exhibit of the American Society of Lubrication Engineers will be held in Buffalo, N. Y. at the Hotel Statler, April 21–23.

ROTOBLAST DESCALING SAVES $75 A DAY



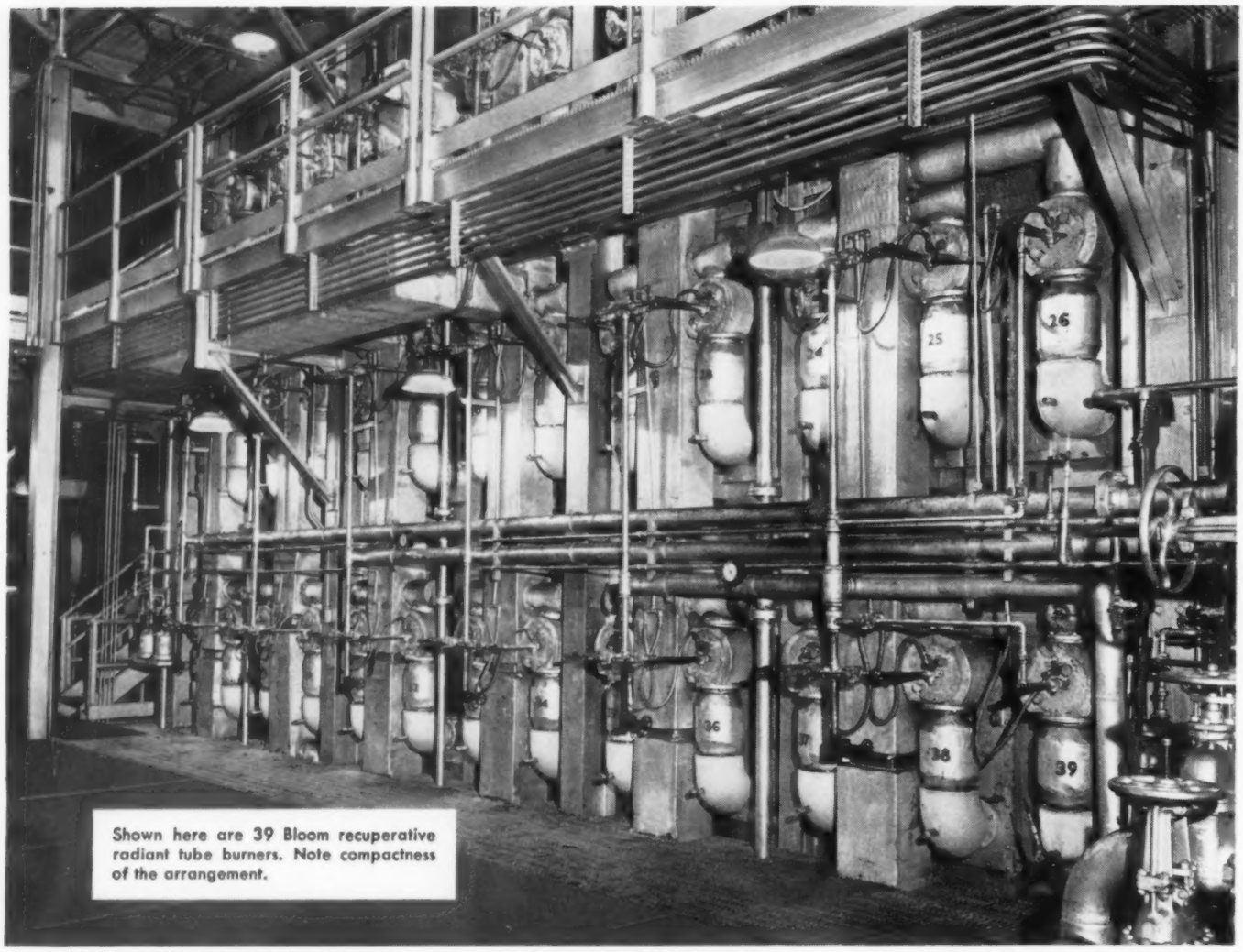
Pangborn Rotoblast Descaling Machine makes cost-cutting automation possible at Bustin Steel

At Bustin Steel Co., Dover, N. J., hot rolled steel bars are descaled by a Pangborn Rotoblast Machine at rates up to 180 linear feet per minute. This speed of operation plus the perfect quality of work—eliminating oiling and degreasing operations later—permits inserting this Rotoblast Machine directly at the head of the production line, working toward a completely automatic manufacturing operation.

The operating cost of this machine saves Bustin at least $75 a day compared to pickling, *plus* the cost of degreasing *plus* savings resulting from longer tool and die life.

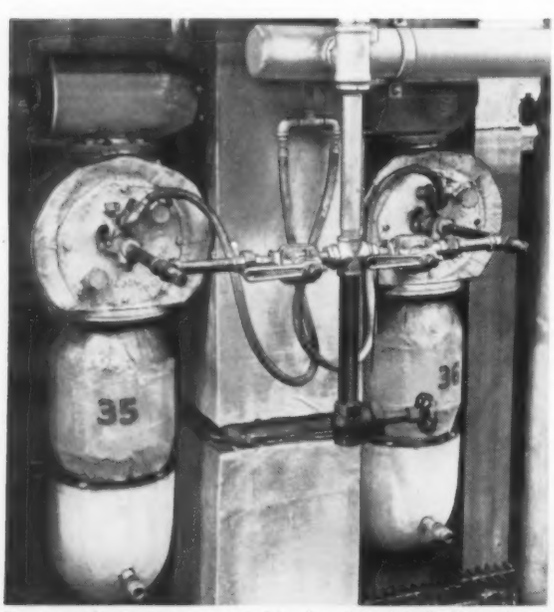
For information on how Pangborn Rotoblast can save *you* money, write PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment and Rotoblast Steel Shot and Grit.*

Pangborn **CLEANS IT FAST WITH ROTOBLAST®**



Shown here are 39 Bloom recuperative radiant tube burners. Note compactness of the arrangement.

208 BLOOM BURNERS heat Weirton's giant furnace



Burner and recuperator are unitized and insulated. Air preheat is 700°F. Continuous-burning, removable pilots are seen above the gas inlets.

Heat to anneal tinplate in the new continuous furnace at Weirton Steel Company is furnished by 208 Bloom Recuperative Radiant Tube burners. The Bloom burners have operated trouble-free for more than a year under severe fuel conditions.

Bloom Radiant Tube burners are designed for operation with coke oven gas, natural gas, butane or oil. Easily-lighted, stable pilots are provided. Alloy construction prevents warping. Proven burner design provides uniformly-heated, clean radiant tubes, thus assuring maximum tube life.

Bloom engineers will gladly cooperate in designing combustion systems employing these or other Bloom burners.

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SYNTRON

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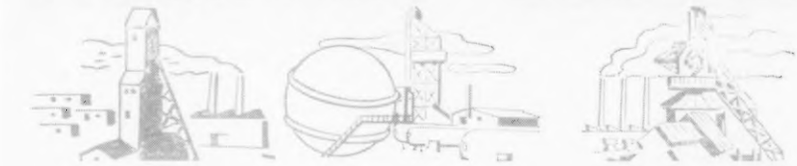
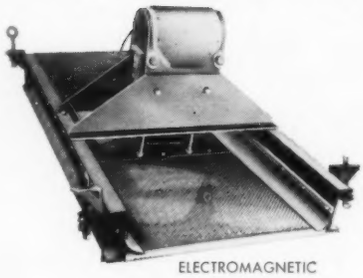
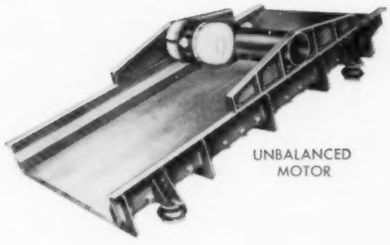
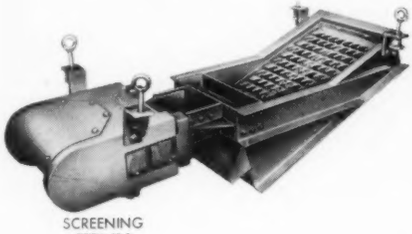




ELECTROMAGNETIC



UNBALANCED MOTOR



SCREENING FEEDERS

COUNTER BALANCED

for efficient, dependable, low cost scalping, sizing or fine screening

SYNTRON builds a vibrating screen for every screening job from heavy duty scalping of ores and limestone, to fine screening of coal, sand, and chemicals.

SYNTRON Vibrating Screens are built in a variety of styles—one, two or three deck models with drive units designed for each particular screen. Available in sizes ranging from 2 feet wide x 5 feet long to 6 feet wide x 14 feet long plus the 4 feet wide x 20 feet long conveyor screen.

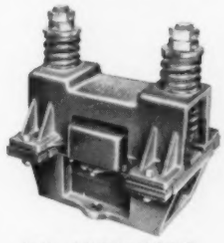
SYNTRON Screens provide uniform vibration, eliminating dead spots. Constant full screen efficiency provides more effective separation and higher capacity.

SYNTRON Screens combine efficiency, dependability and low maintenance to give better separation, greater tonnage at lower cost.

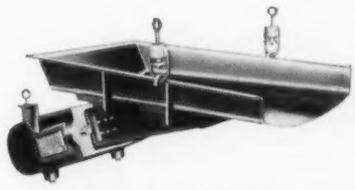
SYNTRON Screens are compact, easy to install, easy to maintain.

Write for complete information on all SYNTRON Screens

Other SYNTRON Equipment of proven dependable Quality



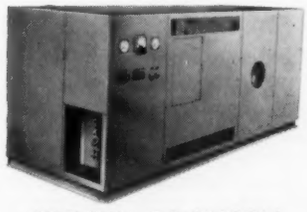
BIN VIBRATORS



VIBRATORY FEEDERS

COUNTER BALANCED VIBRATING CONVEYORS

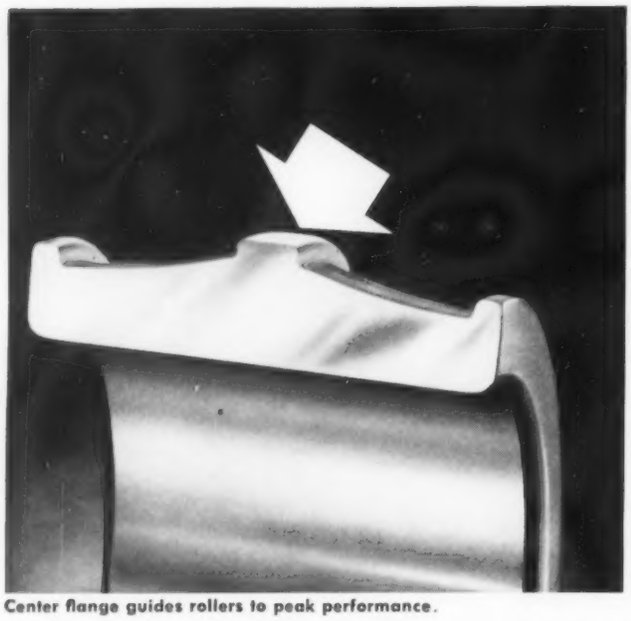
ROLL NECK SEALS



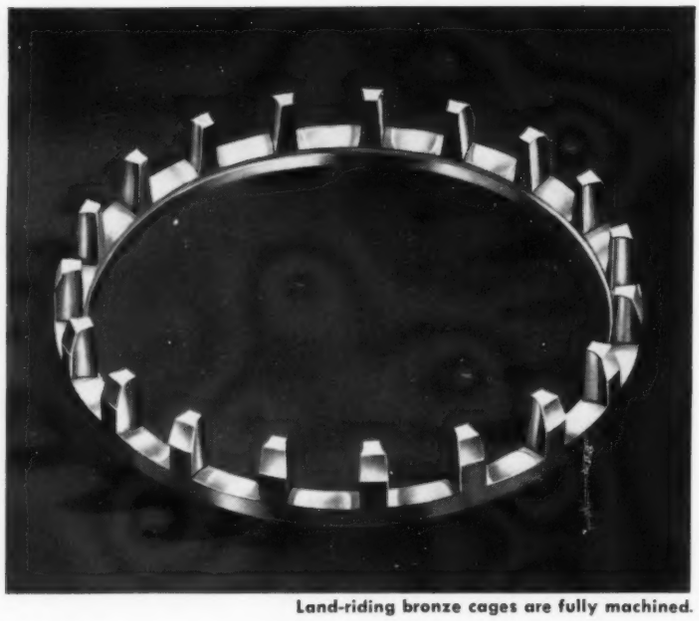
SELENIUM OR SILICON RECTIFIER POWER UNITS

SYNTRON COMPANY

699 Lexington Avenue — Homer City, Penna.

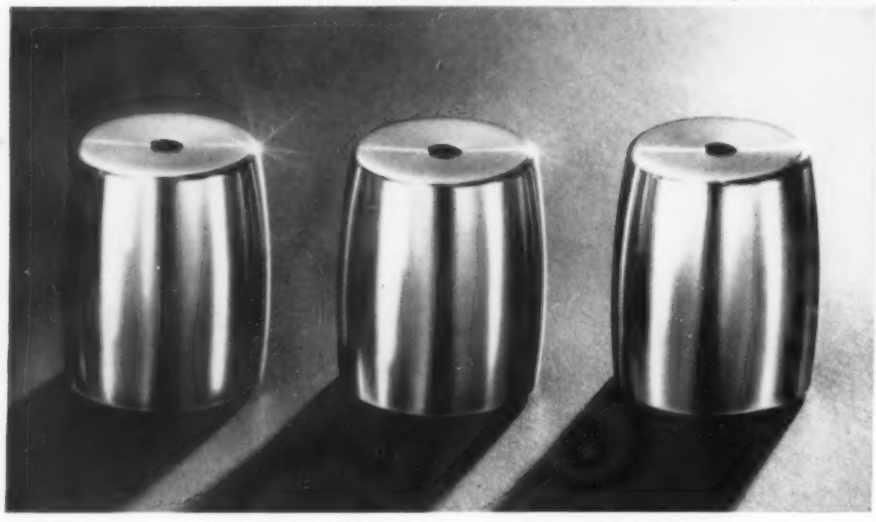


Center flange guides rollers to peak performance.



Land-riding bronze cages are fully machined.

Roller diameters are matched electronically within .0001".



Consider every design feature and you'll choose Torrington!

Torrington has compromised none of the operating design features of its Spherical Roller Bearing, because application experience has proved them essential to superior bearing performance.

There's no substitute for the stabilizing effect of the integral center guide flange. Torrington's asymmetrical roller seeks this flange under load. Skewing and stress concentrations are eliminated. Every roller carries its share of the load, for roller diameters are matched electronically within .0001" for even load distribution.

Rollers are precisely spaced by fully machined land-riding bronze cages that withstand even the high stresses of eccentric service. Two independent cages, one for each row, prevent roller drag and side stresses under thrust loads. Size-stabilized races prevent "growth" or change in dimension in service.

These features mean a cooler-running, longer-lasting bearing. When you buy bearings, look into *every* detail, and you'll choose Torrington. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

Superior performance features of
TORRINGTON SPHERICAL ROLLER BEARINGS:

- Integral guide flange for roller stability
- Asymmetrical rollers seek flange for positive guidance
- Electronically matched rollers
- Size-stabilized races
- Fully machined land-riding bronze cages
- Controlled internal clearances
- Even load distribution
- Inherent self-alignment
- Long service life

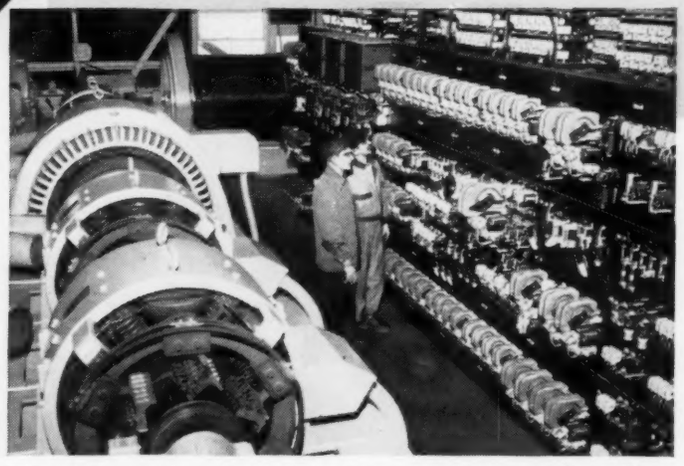
Send for new Spherical Roller Bearing Catalog No. 258

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

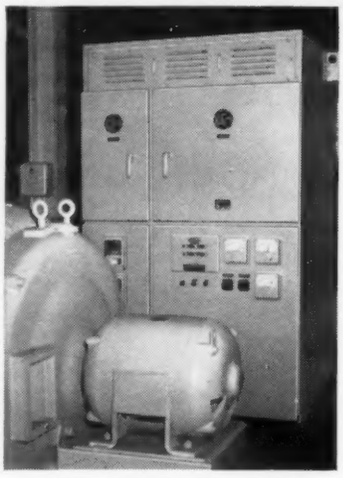
1800-TON-PER-HOUR DRAVO UNLOADER IN OPERATION AT PENNSYLVANIA RAILROAD'S GREENWICH POINT, PHILADELPHIA, ORE UNLOADING PIER

You're Under Way *Fast* WITH EC&M ADJUSTABLE VOLTAGE CONTROL!

EC&M Adjustable Voltage Control Panel *(mounted on trolley)* for Hold and Close Line Motors and for Trolley Motor, plus Protective Panel for other drives.



EC&M Control Panels for Hold Line, Close Line, Trolley, Turntable, Quadruplex Travel, Rail Clamps and Apron Hoist Motors are mounted in Machinery room, 100 feet above ground level, along with generators which supply DC power for unloader motors. Power resistors, mounted above Panels, are EC&M TAB-WELD.



EC&M Type ZHA 4160 Volt Starter provides pushbutton starting of 800 HP Elliott synchronous motor driving 4 generators.

This Dravo Unloader is typical of many prominent installations on which EC&M has worked with both unloader and motor builders to get machines into production quickly with minimum adjustment and "tune-up" time.

Equipped with a total of 20 motors ranging in size from 10 to 800 HP, this unloader takes giant-sized bites (22½ tons) of ore from a ship's hold on an average cycle handling time of 45 seconds. Frequently, the skilled operators lower the time to 36 seconds per trip.

The bucket (hold and close line motors) and trolley drive are operated by adjustable voltage control under current limit acceleration through rotating regulators. Constant potential control is used for the travel, rail clamps, turntable and apron hoist.

EC&M is prepared to supply complete equipment including control, brakes, limit stops and all rotating machinery. When planning adjustable voltage installations, consult EC&M for engineering assistance.

Photos courtesy Dravo Corporation, Elliott Company and the Pennsylvania Railroad

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

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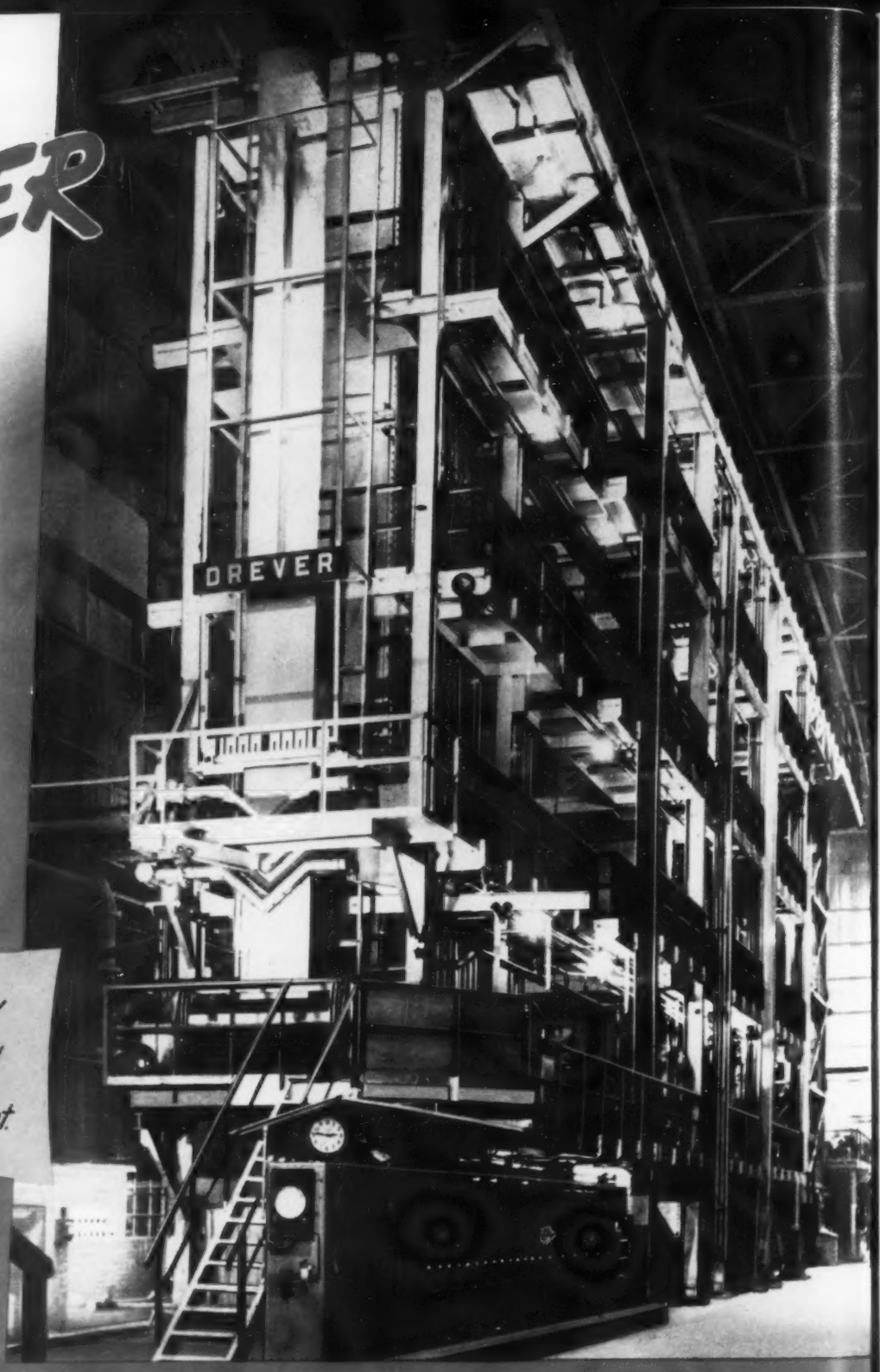
DREVER

Continuous STRIP ANNEALING FURNACE LINE



Delivery end of furnace for low carbon tin plate strip installed in a large Canadian steel plant.

This furnace has an installed electrical input in heating and soaking zones of 3000 KW for a rated production of 37,000 lbs/hour on .0099″ x 33″ wide strip running at 550 FPM.

Furnace equipment is designed to handle strip in thicknesses from .0075″ to .020″ in widths varying from 19″ to 38″.

HNX atmosphere gas is used to purge the furnace.

DREVER COMPANY ..... RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.

HAGAN NEWSLETTER
Behind the Panel

THE QUALITY OF MEASUREMENT FIXES THE QUALITY OF CONTROL

Control can only be as precise as the measurements on which it is based. Not only the measurement, but also the means by which it is transmitted to the recording or actuating mechanisms must be as near perfection as possible if a high degree of control quality is to be maintained. Here are some examples of how Hagan achieves exact control by means of accurate measurements:

MEASUREMENT SPAN CRITICAL IN REDUCING TEMPERATURE VARIATIONS

A large eastern steel mill was seeking a temperature controller for continuous strip annealing furnaces—a process that threads light gauge, cold rolled steel through the high temperature furnace in the range of 800 ft/min and provides fully recrystallized steel, ductile in spite of its relative hardness, with other desirable physical properties. They set up a Hagan PowrAmp and a competitive controller side by side on two new furnaces. The suppressed range feature of the PowrAmp made possible the holding of temperature variations to 2-3F—its span was set at 1,500 to 1,700F for the test. On the basis of these very acceptable results, which the competitive controller could not match, the PowrAmp was put in control of the temperature on these two lines. Later, when two more annealing lines were added, PowrAmp temperature controllers were selected—resulting in Hagan control of all four annealing lines at the mill.

SOAKING PIT REAL TEST OF METER TURNDOWN RANGE

When ingots start to heat in a soaking pit, maximum fuel firing is required. But later in the cycle, only enough fuel to maintain the desired temperature is needed. This may be less than 10% of max. Hagan Ring Balance gas and air flow meters, calibrated for a maximum differential of 10"WC, are accurate with as little differential as .035"WC, or about 6% of the full scale of the meter. This means that fuel-air ratios are maintained exactly throughout the full soaking pit cycle. Particularly critical when special alloys are being heated, precision ratio control pays off across the board in maintenance of quality and in fuel savings. (Item C-1)

MEASURING STEAM FLOW WITHOUT A PRIMARY ELEMENT SAVES MONEY

High pressure steam flows may be measured without the use of a primary element in applications where the Reynolds number is in excess of 10,000,000. Since the line loss produced through a certain length of pipe cannot be predicted as accurately as with an orifice plate, it is a necessity that the meter connected to measure the loss have an adjustable range to accommodate the unpredictable differential that can be established only after start up. Due to its wide range of adjustment, the Hagan Ring Balance meter makes feasible the accurate measure of steam flow using pipe friction as the source of differential. This eliminates the need for installing a very expensive, high-alloy flow nozzle in the steam line. (Item C-2)

MUST HAGAN HIGH QUALITY BE HIGH COST?

Public Utilities have learned that this is not the case. The utilities are bound by law to select new equipment on the basis of competitive price and comparable quality. Here is the score for the last 58 new boiler control systems awarded as a result of this competitive bidding:

	Successful Bids		Successful Bids
HAGAN	19	Company "C"	3
Company "A"	19	Company "D"	2
Company "B"	13	Company "E"	2

(Item C-3)

HAGAN CHEMICALS & CONTROLS, INC.

Hagan Building, Room 702, Pittsburgh 30, Pennsylvania
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy

If you would like more information on any of the above items, check the appropriate box below.

☐ Item C-1 ☐ Item C-2 ☐ Item C-3

At B-L-H the proof of the welding is in the testing... X-rays of giant pressure vessel showed not one defect!

Automatic submerged metal arc was one of three welding methods employed by B-L-H's Eddystone Division on this 100-ton vessel.

Chrome molybdenum steel 5 1/16 in. thick was carefully preheated prior to tack-welding. Shown is a profile of the joint, beveled by flame cutting between half-cylinders.

The 100-ton pressure vessel illustrated was fabricated at the B-L-H Eddystone Division by welding together two half-cylinders, 12 ft. long, 6 ft. in radius, and made of 5 1/16-in.-thick chrome molybdenum steel. Then these had to be joined at top and bottom to hemispherical heads of the same material 2⅝ in. thick. The ends of the cylinder walls had to be tapered from the outside so that the walls and heads would be of the same thickness at the joint. Joint design for the longitudinal welds called for 64 passes to be built up in a balanced manner, first on one side of the cylinder wall, then on the other, to avoid uneven stresses.

Welding several nozzles to the heads presented some unusual problems. One such weld required 92 passes. In all, 13 kinds of steel ranging from ⅜ in. to 5 1/16 in. in thickness were used.

All root passes, all joints that were back-chipped, and all completed welds were examined by magnetic particle inspection. Also, as a requirement of the job, all welds in the piping and the vessels were subjected to a 100% radiographic inspection with 1-curie sources of cobalt-60. At this point the care and precision with which the welding had been planned and executed became dramatically evident. No defects were found and no repair welding was necessary.

Only a shop with Baldwin's wealth of skills and facilities could have handled this tough job so efficiently ... so economically.

A copy of our illustrated Weldment Bulletin 7001 is yours for the asking.

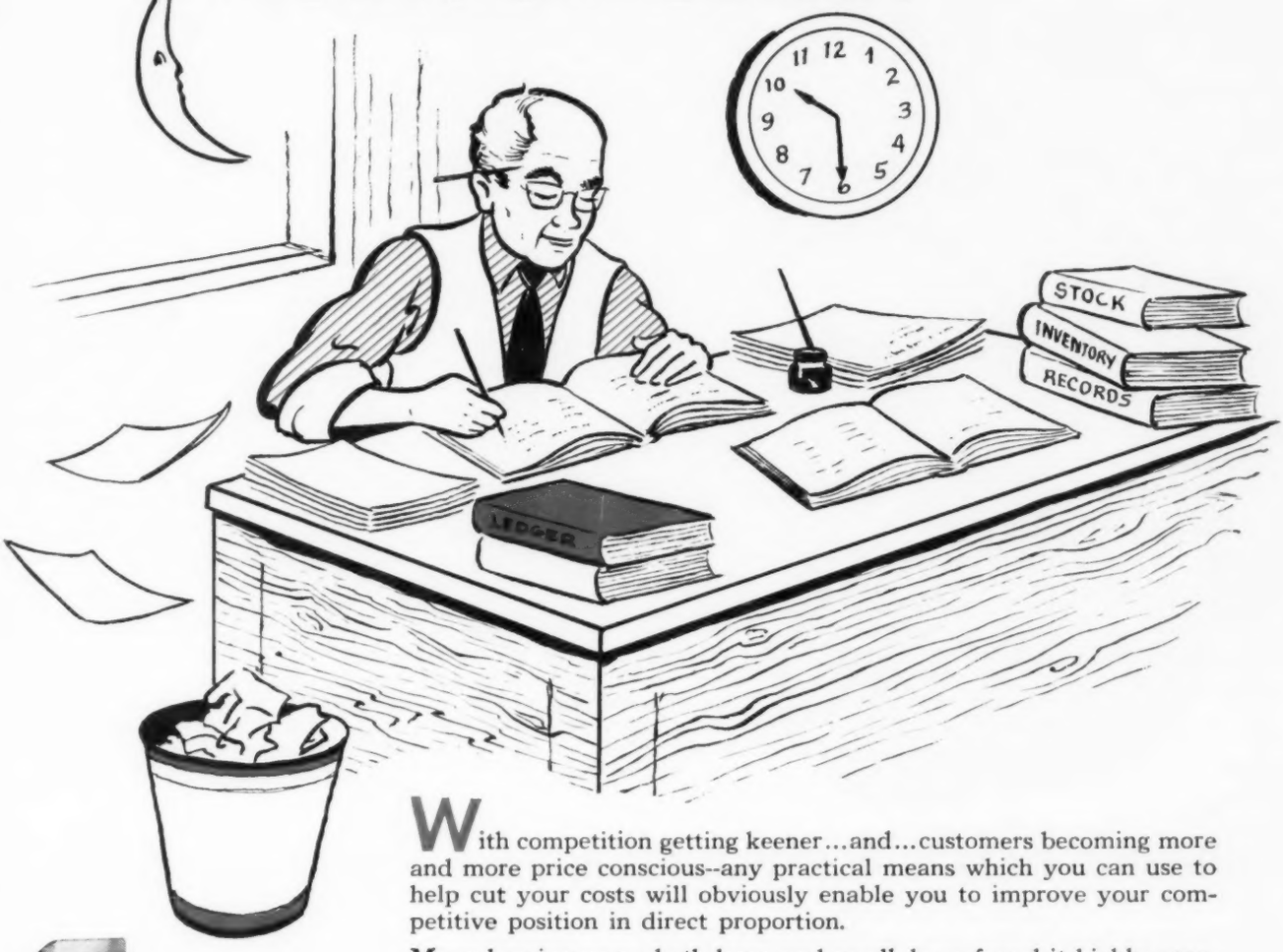
BALDWIN · LIMA · HAMILTON

Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings • Special machinery • Bending rolls • Machine tools

Less record keeping--
Lower cost!



With competition getting keener...and...customers becoming more and more price conscious--any practical means which you can use to help cut your costs will obviously enable you to improve your competitive position in direct proportion.

Many bearing users, both large and small, have found it highly practical and decidedly profitable to use Berry's inventory as *their* inventory. By so doing they can safely reduce their own inventory to a minimum--and eliminate a lot of costly record keeping. In addition, they save on storage space, insurance, and taxes, besides.

Like so many others, you can gain the same advantages--because Berry can give you **immediate delivery** on *anything* and *everything* you require--from a regular stock of over 50,000 different types and sizes of bearings, bearing specialties, and transmission appliances. Why not phone bearing headquarters--NOW.

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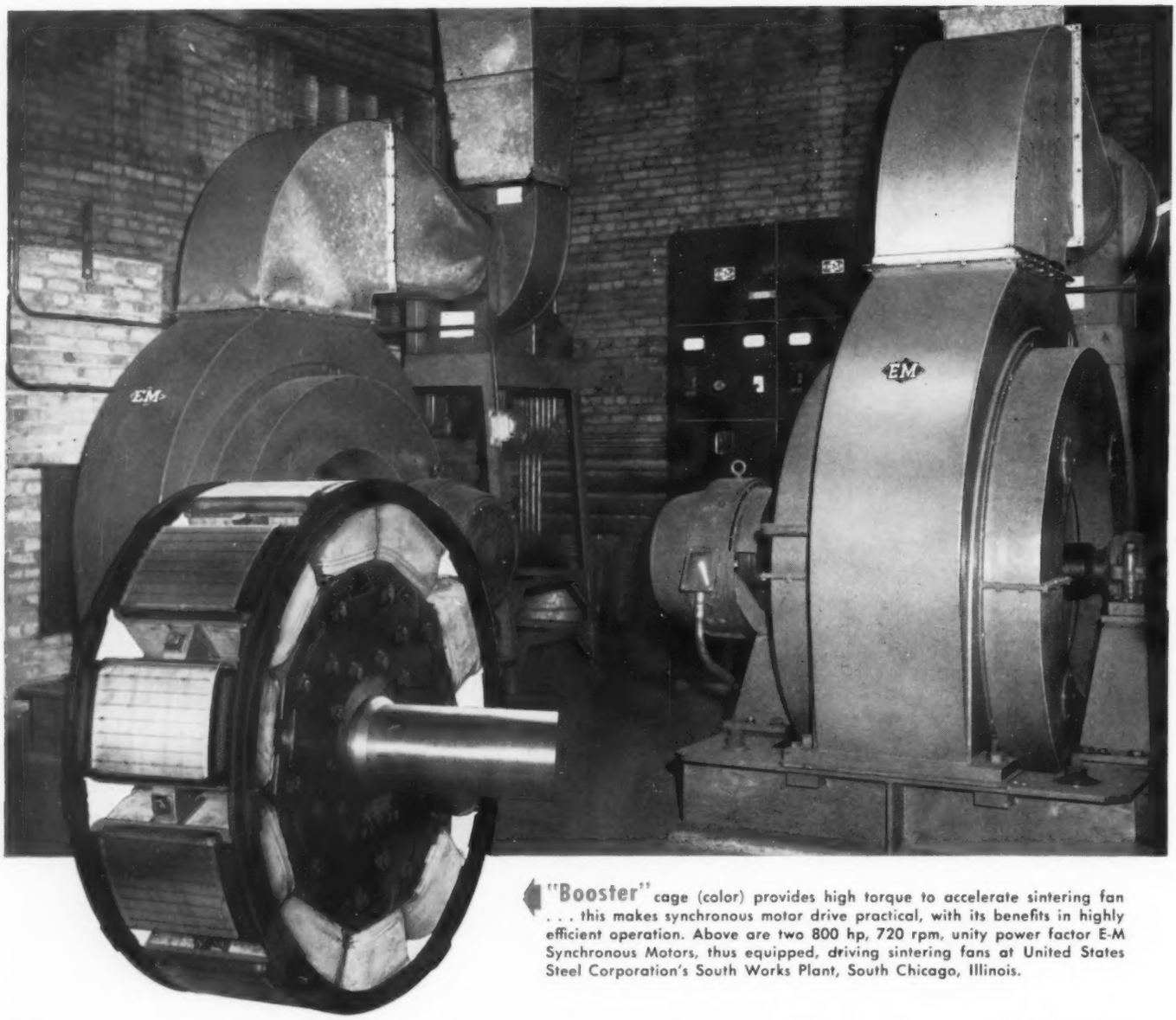


"Booster" cage (color) provides high torque to accelerate sintering fan . . . this makes synchronous motor drive practical, with its benefits in highly efficient operation. Above are two 800 hp, 720 rpm, unity power factor E-M Synchronous Motors, thus equipped, driving sintering fans at United States Steel Corporation's South Works Plant, South Chicago, Illinois.

How to drive a sintering fan most profitably

● There are sound reasons why synchronous motors (such as the installation above) are the most economical sintering fan drives. Consider your power bill . . . the high efficiency of the synchronous motor produces maximum usable horsepower from a minimum of electric power. Your entire electrical system will benefit from power factor improvement through the unique ability of synchronous motors to correct lagging power factor. You save on power costs both ways. And motor maintenance costs are low too.

However, the fans have a large WK^2, and sintering begins with a cold bed. So, E-M engineers developed a special double-deck starting cage for these difficult starting and synchronizing requirements. Here's what it does:

Characteristics of this E-M extra-heavy-duty double-cage winding are such that uniformly high torque is provided for both starting and pull-in. This E-M winding not only accelerates the heavy fan, but also provides that powerful "boost" to 98½% of synchronous speed needed to pull it into step.

Further assurance of powerful synchronizing is offered by the E-M-invented Polarized Field Frequency Control which automatically applies field excitation at the instant when rotor angle will give maximum synchronizing power with no pole slippage. Current inrush is held at a minimum.

E-M's pioneering and long experience in synchronous motor applications have resulted in many profitable steel plant installations. Ask your nearest E-M sales engineer for his practical suggestions on your requirements.

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

1100-TPA-2146

E-M

Specialists in making motors do
EXACTLY WHAT YOU WANT THEM TO

We learned a lesson from a lineman

"*Safety* is where I shine," one of our linemen told us recently. "Safety's one of the most important parts of my job. But *saving*—and that's important, too, for a family man—that's too tough. Why don't you guys in the office make it easy for us—like that Payroll Savings Plan for U.S. Savings Bonds?"

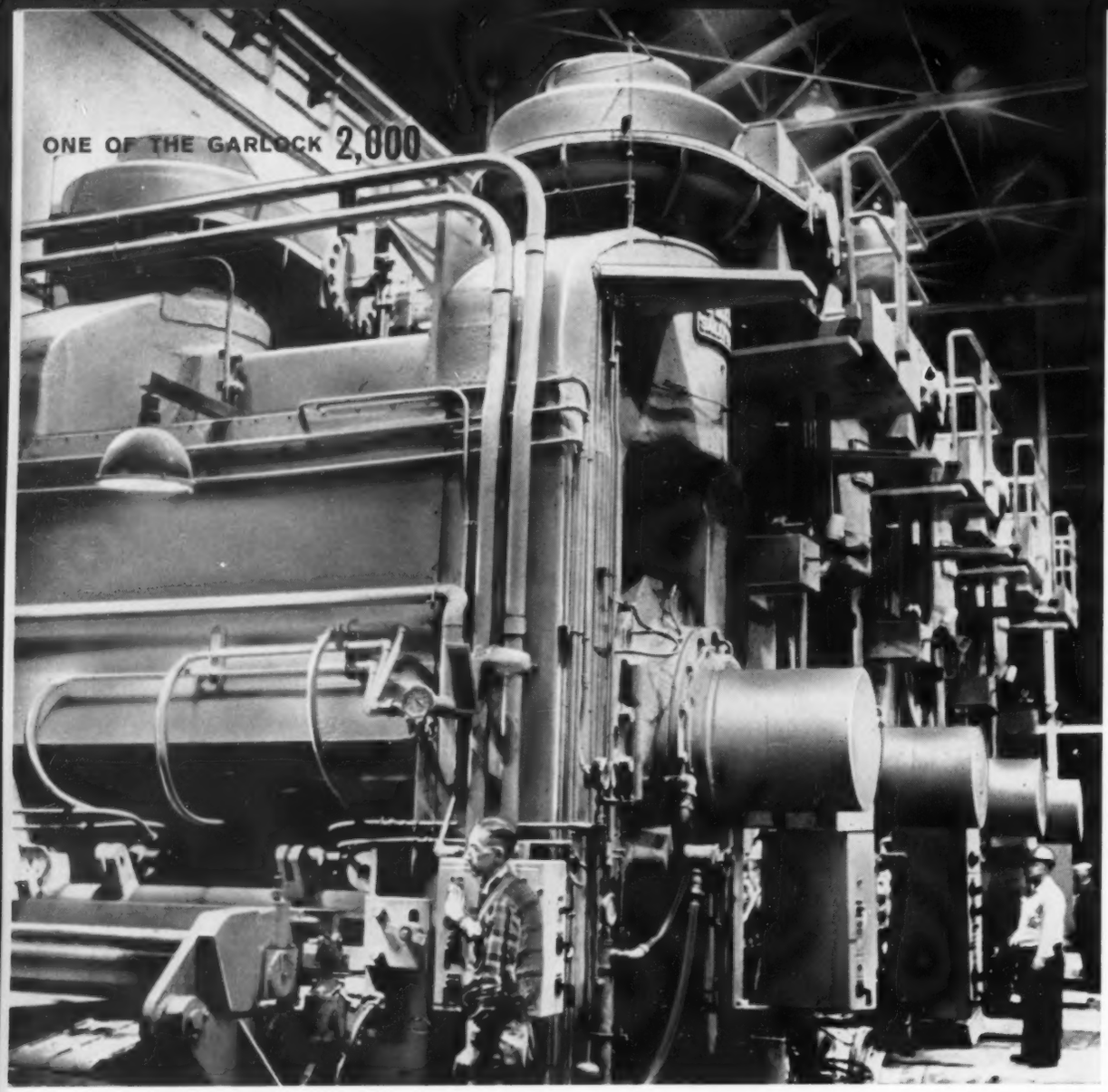
Of course, that is *exactly* what we want to do for *every one* of our people. We explained that to our lineman. But he certainly made us stop and think. Because if *he* didn't know about our plan for buying U.S. Savings Bonds through Payroll Savings, then many other employees must be in the same position.

We telephoned our State Savings Bond Director for help. He worked out a company-wide campaign for us. Application cards were placed in the hands of every person on our payroll. We had a *fair* participation when the campaign started. But within days afterward, we had an *excellent* percentage of bond buying employees.

It shows that practical people welcome a chance to set up this sound savings plan. Today, particularly, there are more payroll savers than ever before in peacetime. Look up *your* State Director in the phone book or write: Savings Bonds Division, U.S. Treasury Dept., Washington, D. C.

IRON AND STEEL ENGINEER

THE U. S. GOVERNMENT DOES NOT PAY FOR THIS ADVERTISEMENT. THE TREASURY DEPARTMENT THANKS, FOR THEIR PATRIOTISM, THE ADVERTISING COUNCIL AND THE DONOR ABOVE



Model 64 assembled KLOZURE for back-up and work rolls. Designed for large shafts, severe service.

Model 82 bonded KLOZURE for back-up and work rolls, normal to high speeds. Comes as large as 44" diameter.

Model 21 or 23 Split-KLOZURE for installation without disassembly of equipment. Medium-speed service.

Model 142 face type KLOZURE for mill rolls. Designed to seal surfaces perpendicular to shaft.

Model 53 assembled KLOZURE for table rolls, normal to high speeds. Withstands temperatures to 250° F.

On all mills—Bearings are fully protected by Garlock KLOZURE* Oil Seals

Everywhere in steel—on hot and cold strip mills, blooming and structural mills, rolling mills—Garlock KLOZURE Oil Seals prevent leakage of vital bearing lubrication. And, they further prevent damage to the bearings by sealing out dirt, spray, and other foreign matter.

Model 142, for example, keeps water splash and scale out of bearings at the shoulder of a mill roll. Models 64 and 82 are ideal for protecting bearings on back-up and work rolls; Model 53 is recommended for table rolls; and, where equipment can't be dismantled easily, Model 21 or 23 split-KLOZURES are the choice.

All KLOZURES are oil and grease resistant . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . withstand temperatures from −40° F. to +250° F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500° F.

KLOZURE Oil Seals are another part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Call your local Garlock representative, or write for Catalog 20.

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

**Registered Trade Mark*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Canadian Division: The Garlock Packing Co. of Canada Ltd.

Plastics Division: United States Gasket Company

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MARCH, 1959

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Note: Post cards expire three months after publication date.

(1) Motor Selector Booklet

A Reliance Electric and Engineering Co. a-c motor selector booklet gives concise selection data to users of a-c motors from 1 through 200 hp. Included in the booklet are brief explanations of NEMA design classes, speed-frequency relationship, current and torque values, as well as frame selection tables and complete dimension information for standard frames and mechanical modifications for all frame sizes from 182 through 6085. Additional photos illustrate special purpose motors made by Reliance for use in unusual temperatures or atmospheres. (Bulletin B-2103-4)

(2) Industrial Spray Nozzles

The Industrial Nozzle Div., Wm. Steinen Manufacturing Co., has announced the publication of a new catalog covering their complete line of industrial spray nozzles. The catalog contains complete listings and data on all types of nozzles for industrial spraying applications. Specific data on spray angles, dimensions, types of connections and capacity vs pressure for all standard nozzles are presented in simplified time-saving selection tables. The catalog is illustrated to give the user specific details of flow and spray patterns that are attained with each type of nozzle. In addition, the catalog contains an applications section. (Catalog No. 59)

(3) Recorder Data Sheet

A data sheet on their new Speedomax Type H resistance ratio recorders for measurement from three-terminal potentiometer type transducers is available from Leeds & Northrup Co. The data sheet describes some features of these recorders, their range, accuracy rating, indicating scale and span step response time. Photos of these new recorders are also included. [Data Sheet ND46-29 (20)]

(4) Air Dump Cars

Magor Car Corp. has available a folder which describes the advantages of their air dump cars. The folder discusses some of the features of these cars, rugged end construction, fast, safe dumping, greater stability with fast opening door mechanism, etc. An illustration pointing out these features is included, as well as photos of the separate sections of the cars.

(5) A-C Network Analyzer

General Electric Co., Computer Dept., has published a folder describing their miniaturized a-c network analyzer. The folder lists the features of this analyzer as well as its specifications. A list of components is included as well as a photo of the front view of the analyzer.

(6) Mill Motor Couplings

The Metal Products Div., Koppers Co., Inc., has published a brochure on the design features and operation of Fast's mill motor couplings. The brochure points out that these couplings are especially designed for use on table rolls, conveyor drives, skew tables, screwdowns and other auxiliary drives, and can be used on direct-connected feed rollers. A table showing mill motor ratings and dimensions is included.

(7) V-Belt Drives

A bulletin published by Dodge Manufacturing Corp. describes a completely new line of V-belt drives that are smaller, cost less, weigh less and require less space than conventional V-belt drives. Illustrated with photographs and engineering drawings, the bulletin explains unique construction features of new Dyna-V sheaves and V-belts, enabling them to deliver up to three times as much horsepower in a given space. Tables of pre-engineered drives make this an easy-to-use manual for plant engineers, design engineers and other users with power transmission problems. Other tables give horsepower capacities, belt speeds, center distances, sheave diameters, etc. Photographs illustrate easy-on, easy-off characteristics of Taper-Lock bushings featured in new line. (Bulletin A-695)

(8) Valves

A complete line of their valves is described in an illustrated catalog published by Barksdale Valves. The catalog is divided into three colored sections according to the type of medium used: oil, water or air, and features manual, foot-operated and solenoid valves. Under manual and foot-operated valves are listed the four-way, shut-off, manipulator and dual pressure valves. Illustrated are the solenoid operated four-way, three-way, shut-off and diverter valve series. Typical flow patterns and illustrations of specific valves, port sizes, ordering data and valve numbers are shown. (Catalog 59-60)

(9) Speed Reducer Folder

"Universal Worm Gear Speed Reducers" is the title of a Link-Belt Co. folder that contains complete data on a new type of reducer. The folder illustrates the various mounting positions that solve problems of space and also contains selection procedures for proper applications. Five tables give service factors, load classes, input horsepower ratings, over-

hung load ratings and thrust load ratings. Dimensions and weights for all three types of mountings—worm shaft below gear, worm shaft on top of gear and output shaft vertical are also graphically described. (Folder 2724)

(10) Slab and Bloom Marker

M. E. Cunningham Co. has available a bulletin detailing their remotely operated slab and bloom marker. The bulletin discusses the application of the slab and bloom marker, its construction and operation as well as its maintenance. Illustrations of the equipment are included. (Bulletin 613-D)

(11) Automatic Air Filter

Construction and operation characteristics of the new Model "B" Roll-O-Matic automatic renewable-media air filter are described in a bulletin released by American Air Filter Co., Inc. Featured in the bulletin is a description of a 65-lineal ft roll of impregnated, reinforced media composed of continuous, slightly curled, interlaced glass filaments that are held in place by a thermosetting plastic bond to form a resilient pad or fluffy blanket having a nominal thickness of 2 in. The filter's construction and completely automatic operation is explained part by part in the bulletin. Dimensions and operating capacities also are included. (Bulletin No. 248-C)

(12) Silicon Chargers

A bulletin describing their complete line of silicon-rectifier chargers has been published by Exide Industrial Div., The Electric Storage Battery Co. One of the features of this bulletin is a chart for determining the proper size and model of silicon-rectifier charger to be used with stand-by batteries. Tabulating information on 27 basic rectifier models, the chart enables the user to select chargers according to number of battery cells to be charged, output amperage and input voltage and phase. It also lists dimensions and weight of each model and specifies whether it can be mounted on a wall, rack or floor. In addition to illustrating typical models, the bulletin also describes features which help maintain constant voltage at battery terminals over a complete range from zero to full load (including the critical 0 to 15 per cent range which covers most float charging). (Bulletin 6258)

(13) Control Valves

A new line of their pilot operated single and double solenoid control valves is described in a bulletin available from Hunt Valve Co. The bulletin lists sizes, dimensions, model numbers, etc. Two position and three position designs; including neutral, compound-on and compound-exhaust actions are also given. (Bulletin No. 582-A)

(14) Variable-Speed Drives

Reeves variable-speed drives are described in a bulletin published by Reeves Pulley Co., Division of Reliance Electric and Engineering Co. The bulletin includes mechanical construction features, condensed drive specifications, available speed variations and accessories for the Reeves Varispeed motodrive, motor pulley and variable-speed transmission. (Bulletin G-5812)

(15) Valves

A single acting, nonreturn valve is fully described in a bulletin issued by the Golden-Anderson Valve Specialty Co. The bulletin contains detailed drawings for elbow, glove and angle body styles and of three yoke styles. It also lists complete dimension tables and gives sample specification. (Bulletin S-2-B)

(16) Instrument and Control Switches

A bulletin released by Allis-Chalmers Manufacturing Co. describes their Type 210 instrument and control switches and discusses their advantages. Outstanding among important features of the switches described in the bulletin are flexibility, accessibility and dependability. The units covered include Allis-Chalmers heavy-duty control switches for use in steel mills, chemical plants and other industrial applications. (Bulletin 14B8112B)

(17) Heavy-Duty Fans

Buffalo Forge Co. has published a bulletin describing their mechanical draft and other heavy-duty fans. The bulletin includes basic data for proper fan selection, performance tables, design sketches, 35 component and installation photos of many types ranging from kiln fans to cyclone compressors. (Bulletin FD-905)

(18) Brazing Data Sheet

An engineering data sheet that discusses a 0.005-in. thick flexible brazing sheet for high-temperature service honeycomb applications is available from Wall Colmonoy Corp. Sizes and weights as well as wetting and flow properties of the sheet are discussed. Advantages, application recommendations and recommended brazing atmospheres are included. (No. 4-A)

(19) Bar and Tube Machinery

Medart bar and tube machinery is described and illustrated in a new booklet available from Blaw-Knox Co. The booklet highlights billet peeling and chipping, centerless turning, bar and tube straightening, stretch straightening, wire straightening and cutting and roll grinding. Twenty-eight pictures point up the advantages of this bar and tube machinery. (Bulletin No. 2533-JJ58)

(20) Electronic Receiver

Specifications for their Powrlog H-O receiver as used in temperature, pH and conductivity measurement and a-c and d-c closed circuit telemetering are discussed in a bulletin available from Hagan Chemicals & Controls, Inc. The catalog contains ten schematic drawings showing different applications of the versatile electronic instrument, including those for d-c voltage and current measurement and a-c and d-c signal transmission and summation. Nine tables showing model numbers for various applications over a wide range of input voltages are also included. (Specification Sheet OE-10003)

(21) Gas-Air Burners

Selas Corp. of America has released a bulletin describing their line of low-cost, precision-built burners. The bulletin points out how the flame stability and wide operating range of the burners make them ideal for a large num-

ber of operations, such as, high-temperature alloy brazing, glass fire, polishing and forming, heating solder pots, liquid heating and others. It also describes how the burners break up the flame front into a large number of small flames, resulting in a concentrated "flat face" round flame of high intensity. A simplified chart showing the burners' wide range of capacities is included. A complete range of sizes, with burner port area, weight and dimensions listed, is also given in table form. (Bulletin PR-1)

(22) Metal-Enclosed Bus Selector

A comprehensive bulletin designed to aid in the selection of metal-enclosed bus for utility and industrial use has been published by the I-T-E Circuit Breaker Co. The bulletin gives ratings and construction details of the company's complete line of isolated phase and nonsegregated phase bus—large-size conductor for high-voltage high-current electrical loads—and bus auxiliary equipment. A six-page section of the bulletin simplifies planning and ordering of isolated phase bus—the type in which each phase conductor is enclosed by an individual metal housing. The section explains how to plan a bus system both electrically and physically, and contains a sample specification to be followed for easy ordering. Included are detailed drawings of bus sections and auxiliary equipment, electrical and physical arrangement diagrams of a typical system, and complete information on bus sizes and electrical characteristics. The bulletin illustrates typical design configurations of I-T-E nonsegregated phase bus—used primarily in lower rating and in-plant applications—and gives ratings available in each. The bulletin also details various auxiliary equipment available for differential relaying, metering, surge protection and bus disconnect. (Bulletin 2604-1A)

(23) Gearmotor Bulletin

The Louis Allis Co. has published a bulletin on its line of right angle gearmotors. The bulletin offers engineering information on gearmotor ratings of ⅓ to 30 hp, single reduction, with output speeds of 23 to 280 rpm. Illustrated in the bulletin are a cutaway view of the gearmotor, its versatility in mounting and the flange mounting arrangements available. Engineering specifications are also given. Class I, II and III gears with open, enclosed or explosion-proof motors are offered. (Bulletin 3050)

(24) Industrial Trucks Selector

The Automatic Transportation Co. has published an industrial trucks selector guide which will be of assistance to all material handling men in setting up new or revising present systems in relation to their specific plant problems. Over 150 models to fit all requirements are illustrated in this booklet. The selection factors, such as: capacity, frequency of use, power source and use of semi-standard or special trucks are also given.

(25) Millivoltmeters

Minneapolis-Honeywell Regulator Co. has published a new catalog describing their noncontrol and control millivoltmeters. The catalog covers operating principles, specifications, features and ordering information on these millivoltmeters. (Catalog C10-1)

(26) Strategic-Udy Process

A simple technique for the electric-furnace smelting and subsequent refining of almost any type of iron ore is fully described in a new 16-page brochure from Koppers Co., Inc. This literature outlines the advantages of the Strategic-Udy Process, includes a layout drawing of a typical Strategic-Udy plant and presents estimated capital and operating costs.

(27) Master Unit Substations

A publication which describes the effective use of master unit substations in handling the protective, transformation and switching problems in both industrial and utility power distribution systems, is available from General Electric Co. Subjects discussed in detail include system reliability, substation flexibility, engineering, unified billing and responsibility, space requirements, appearance, installation, maintenance, ordering, ratings, and dimensions. Included are photographs of industrial and utility applications for use in explanation of subjects, line drawings of network arrangements and a back-cover pocket containing rating and dimension information. (GEA-3800D)

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First Class Permit No. 1965, Sec. 34.9, P.L. & R. Pittsburgh, Pa.

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1010 EMPIRE BUILDING
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IRON & STEEL ENGINEER

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55	CLARK CONTROLLER CO., THE	BULLETIN 106-B	Magnetic brakes
56	CLEVELAND TRAMRAIL DIV., THE CLEVELAND CRANE & ENGINEERING CO.		Tramrail cranes
57	CLEVELAND WORM & GEAR CO., THE	BULLETIN 145	Speed reducers
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64	GENERAL ELECTRIC CO.	BULLETIN GEA-6858	Punched steel grid resistors
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76	SPRAYING SYSTEMS CO.	CATALOG 24	Spraying nozzles
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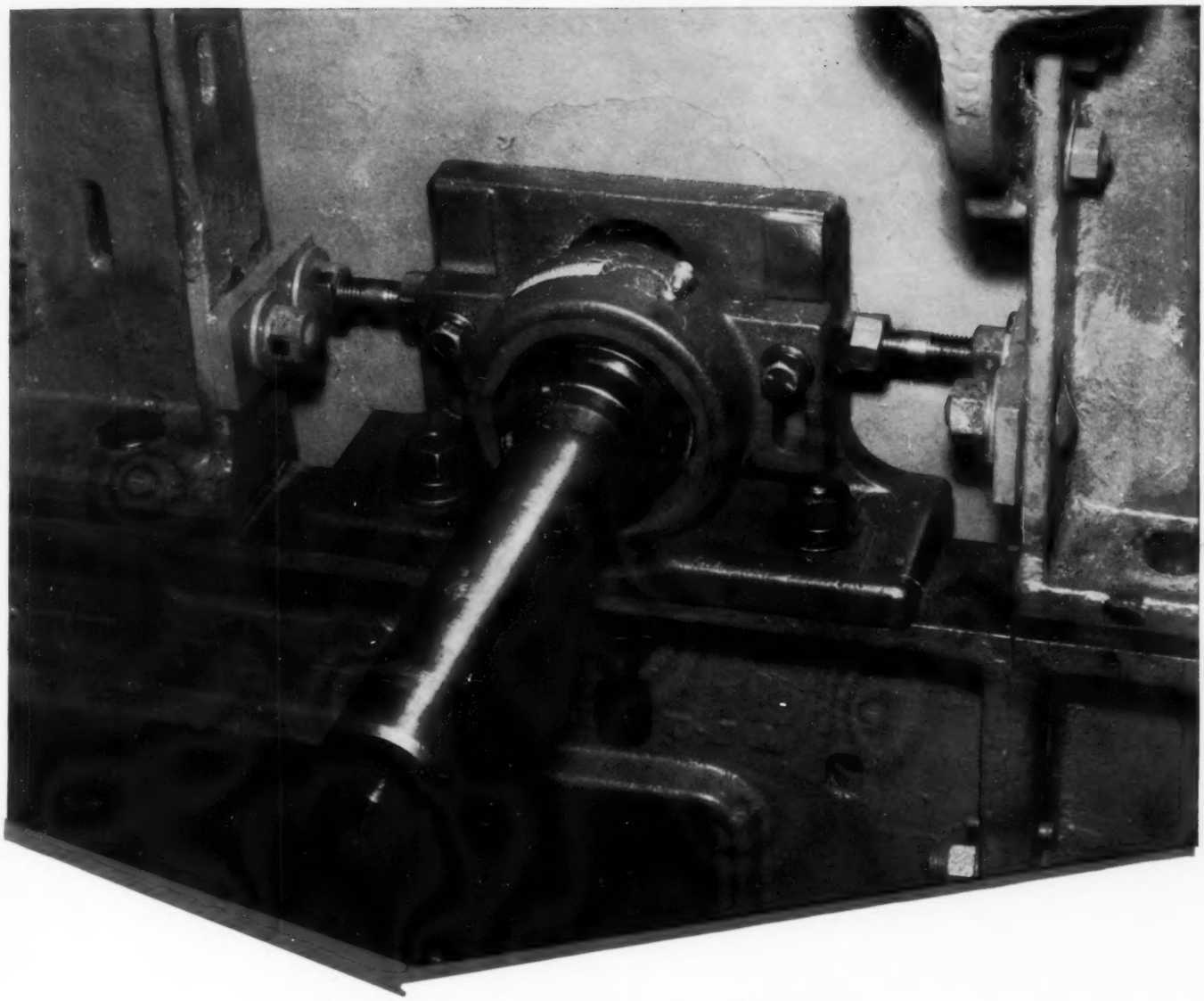

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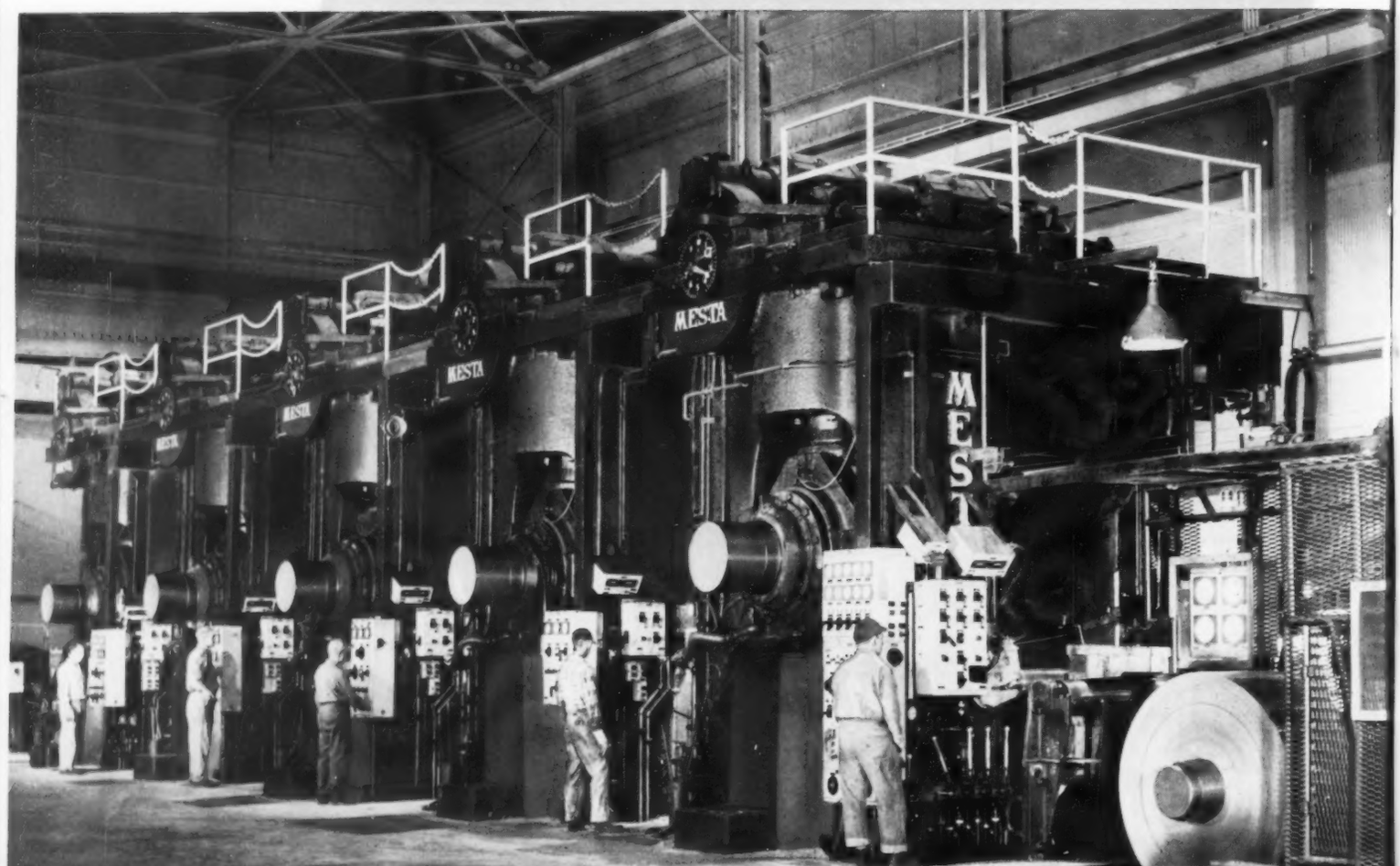
MESTA Cold Mills



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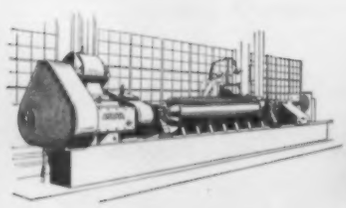
Rolling Strip Steel for Tin Plate in Coils



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Personnel News...

Floyd S. Eckhardt, an assistant general manager of the Lackawanna, N. Y., plant of Bethlehem Steel Co., was appointed an assistant to vice president of Bethlehem's Steel Division, with headquarters at Bethlehem, Pa. **Robert H. Meyer,** coke ovens superintendent at Lackawanna, succeeds Mr. Eckhardt as an assistant general manager. **James C. McCord,** assistant superintendent of coke ovens, was advanced to superintendent to succeed Mr. Meyer. **Charles A. Trageser** and **Russell C. Downes** were made assistant superintendents of coke ovens.

August J. Breitenstein was named assistant vice president—raw materials of United States Steel Corp. He joined U. S. Steel as a mining engineer with the H. C. Frick Coke Co. in 1941 after some ten years' experience in the anthracite fields of eastern Pennsylvania. He was made assistant chief engineer in 1942 and chief engineer in 1944. In 1953 he was appointed director of planning in the raw materials division of U. S. Steel and, in 1954, was named director—exploration and planning, the position he held prior to his present assignment.

George H. Greene has been appointed general manager of the Johnstown, Pa., plant, Bethlehem Steel Co., to succeed the late **A. J. Fisher.** Mr. Greene joined Bethlehem, at Bethlehem in 1926 in the rolling mills, and was transferred to Lackawanna in 1927, working in the rolling mills, construction, electrical and engineering departments until 1946. In 1946 he was promoted and moved to Steelton as chief engineer. In 1949 he became chief engineer at Johnstown, and in 1952 was named assistant general manager.

Charles C. Morgan has been named general superintendent of Geneva Works, Columbia-Geneva Steel Div., U. S. Steel Corp., succeeding **A. E. Terry,** who has retired. Mr. Morgan has been general superintendent of the Pittsburg, Calif., works. **George W. Jedenoff** succeeds Mr. Morgan. Mr. Terry has spent 35 years in the iron and steel industry. He began his steelmaking career in 1924 at the Ironton Plant of Columbia Steel, which later became a subsidiary of U. S. Steel.

John D. Saussaman has been appointed assistant general superintendent, Iron and Steel Div., Kaiser Steel Corp. Formerly division superintendent, Mr. Saussaman succeeds **Clarence R. Lohrey** who was named consultant to handle special projects in the Iron and Steel Division. Mr. Saussaman came to Kaiser in 1946 as assistant superintendent of the Blast Furnace Dept. He was named superintendent in 1948, and in 1957 was appointed division superintendent.

Reynold C. MacDonald has been appointed assistant general superintendent, Primary and Pipe Mills, Kaiser Steel Corp. Prior to his new appointment, Mr. MacDonald was division superintendent, Rolling Mills.

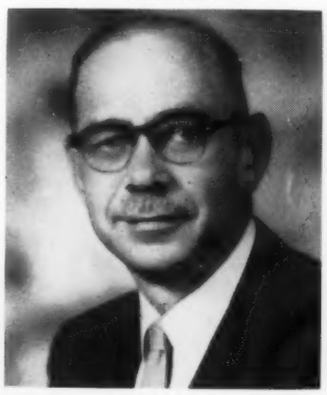
Robert P. Bremner was elected vice president, raw materials, The Youngstown Sheet and Tube Co. At the same time, **Donald S. Day**, was elected vice president, traffic; **Dr. Karl L. Fetters,** vice president, research and development; and **James D. Sloan,** vice president, purchasing.

Mr. Bremner joined the Youngstown Sheet and Tube Co. in 1948 and soon was appointed mining engineer. In 1951 he was advanced to assistant to the vice president in charge of operations and in 1955 was made manager of mining operations. In 1956 Mr. Bremner became assistant vice president.

Mr. Day joined Youngstown Sheet and Tube in 1954 as assistant general traffic manager. He became general traffic manager in 1956.

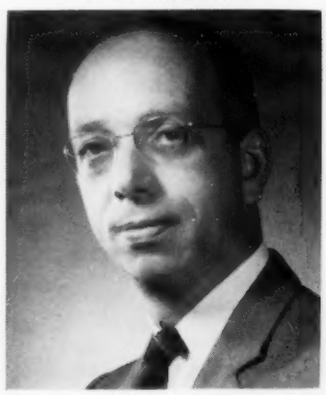
Dr. Fetters first joined Youngstown Sheet and Tube as open hearth metallurgist in 1936, held various positions with the company and teaching positions at Carnegie Tech. In 1943 he returned to Youngstown Sheet and Tube as special metallurgical engineer on the staff of the operating vice president. He was named assistant to the vice president in charge of operations in 1950 and became assistant vice president in 1956.

F. S. ECKHARDT



R. H. MEYER

J. C. McCORD



A. J. BREITENSTEIN

H. M. BANTA

M. L. BERNSTEIN

R. C. McMICHAEL

H. E. HOBE

Mr. Sloan began work as a clerk in the Merchant Mill of Youngstown Sheet and Tube in 1929. After advancing through various positions he became purchasing agent in 1945. In 1956, Mr. Sloan assumed supervision of all of the activities of the purchasing department.

H. Maurice Banta has been appointed assistant director, research and technology, for United States Steel Corp.'s National Tube Division. Mr. Banta joined Jones & Laughlin Steel Corp. as a research metallurgist in 1930 and in 1942 became associated with Battelle Institute.

Michael L. Bernstein has been named chief engineer, Wheeling Steel Corp. Mr. Bernstein started his career with Wheeling in 1949 as assistant chief plant engineer at the Steubenville Works. In 1951, he became chief plant engineer at Steubenville and, two years later, was promoted to the post of superintendent of utilities. He has been assistant general manager of the Steubenville Works since 1957. Prior to joining Wheeling he was project engineer with A. J. Boynton & Co., and chief engineer with Tate-Jones and Co.

Robert C. McMichael has been promoted to assistant manager—steel plants at Lukens Steel Co. In his new position, he will co-ordinate the various functions necessary in the startup of the company's new 140-in. slabbing mill in addition to his regular responsibilities. He has been with Lukens since 1946, most recently as assistant to the manager of the Steel Plants Division.

Harold E. Hobe was named chief engineer of United States Steel Corp.'s Johnstown, Pa., Works. He was formerly superintendent of the maintenance shops at the corporation's Edgar Thomson Works, Braddock, Pa. Mr. Hobe joined U. S. Steel in 1930 as assistant steam engineer at the Mingo Junction, Ohio, Works. In 1936 he was appointed assistant chief civil engineer at the Edgar Thomson Works, and served at that plant as assistant construction engineer, construction engineer and general supervisor of design engineering before his appointment as superintendent of the maintenance shops in 1956.

A. T. Forrest has been appointed chief engineer at Crucible Steel Co. of America's Midland Works. He succeeds the late **J. K. Watkins.** Mr. Forrest joined Crucible in 1946 as construction and maintenance engineer at the Park Works. He became design engineer in 1947, general supervisor of drafting in 1950, acting chief engineer in 1953, and chief engineer in 1954. He was transferred to the Midland plant in 1956 as assistant chief engineer, a position he held until his present appointment. Previously he had served with United States Steel Corp.

E. E. Moore, assistant to the president and vice president, United States Steel Corp., has retired. He will be temporarily retained by the corporation in an advisory capacity. Mr. Moore began his business career in 1919 at Gary, Ind., with the American Sheet & Tinplate Co., a subsidiary of United States Steel, and in 1932 became assistant to the operating vice president of the Illinois Steel Co. He became, successively, general superintendent of the Carnegie-Illinois Steel Corp.'s South Works and Gary Steel Works; vice president of industrial relations, Carnegie-Illinois, and vice president of industrial relations administration, United States Steel Co. He assumed his present position in 1953.

Thomas A. Pope has been named assistant superintendent of the Seamless Tube Mill at Republic Steel Corp.'s Chicago, Ill., plant. **James P. Sullivan** has been appointed assistant to the superintendent of the plant's Open Hearth and Electric Furnace Department. Mr. Pope, who has been with Republic at the Chicago plant since 1951, started as a mechanical engineer. Since 1953 he has been assistant general foreman of the Seamless Tube Mill. Mr. Sullivan has been at Republic's Chicago plant since 1947, during which time he has served as a third and second helper, general foreman and junior melter in the Open Hearth and Electric Furnace Department.

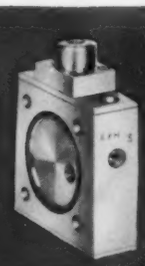
T. A. POPE

J. P. SULLIVAN

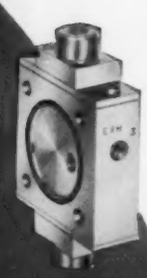
Palm Operated, Detented or Spring Return.

Lever Operated, Detented or Spring Return.

Ball Actuated Spring Return.



Pilot Operated Spring Return.



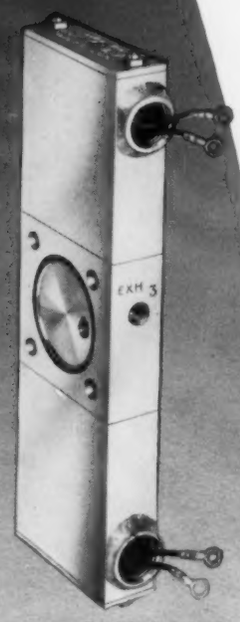
Double Pilot Operated.

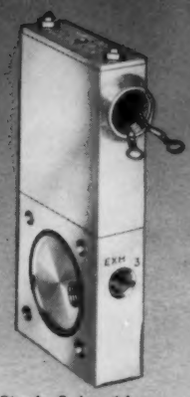
HUNT

new unique Slim Line

CONTROL VALVES

Pilot Operated Bucking Cylinder Return.





Single Solenoid Spring Return.

Double Solenoid Momentary Contact.

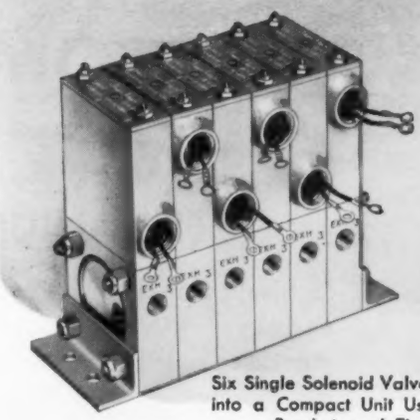
Now available with 8 types of operators. 3-way and 4-way actions. Easily manifolded into compact control centers.

● You'll like these new valves. Only 1″ thick by 3″ wide, they are exceedingly compact and light in weight; can be mounted easily on machines even when space is extremely limited.

Ideally suited for controlling small cylinders, to operate pilots and similar services. ⅛″ or ¼″ pipe tapped. Pressures to 125 p.s.i. Air, water, oil or vacuum service. Stock delivery.

Solenoid valves have the following features as standard; manual over-ride; ½″ NPT conduit connections; valve inoperative with solenoid cover removed.

The side of each valve is counter-bored, trepanned for an "O" ring, and provided with four through holes permitting up to eight valves to be manifolded together and operated from a single supply. Better get full details — now!



Six Single Solenoid Valves Manifolded into a Compact Unit Using Standard Brackets and Tie Rods.

More startling HUNT designs to come!

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Quick-As-Wink® AIR AND HYDRAULIC CONTROL Valves

Send for the "SLIM LINE" Bulletin No. 581 TODAY!

Manufactured by HUNT VALVE COMPANY, 1921 East Pershing St., Salem Ohio

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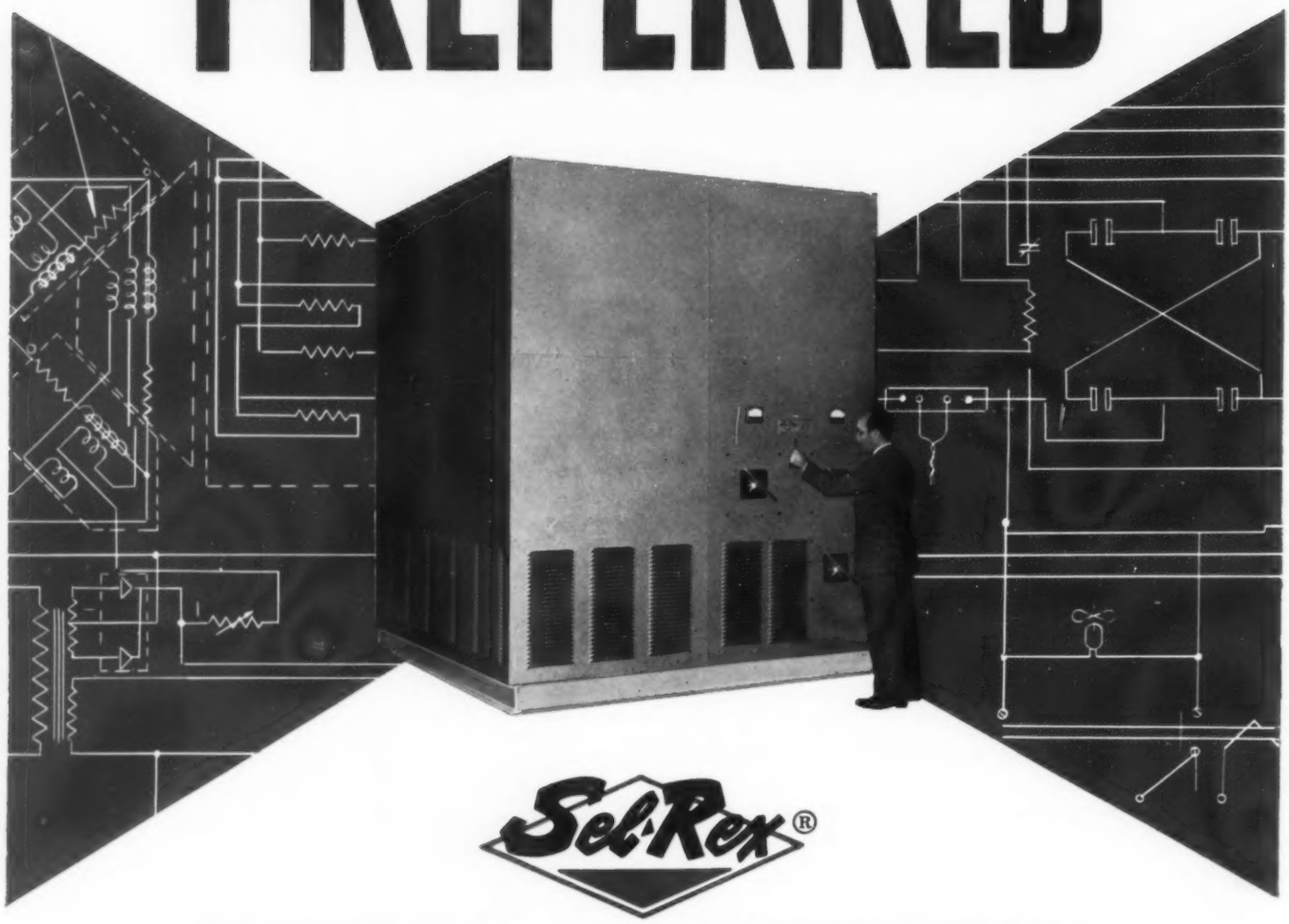

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Rectifier Division

SEL-REX CORPORATION
NUTLEY 10, NEW JERSEY

Complete Semiconductor Power Conversion Systems for any A.C. to D.C. application.

Frank J. Zupancic has been named superintendent of the electrical department of Republic Steel Corp.'s Warren, Ohio, plant. He succeeds **J. S. Rinda** who has retired from the company. A veteran of 25 years with Republic, Mr. Zupancic started with the company as an electrical helper at the Chicago steel plant in 1933. He subsequently became electrical foreman and foreman of the electric shop and in 1946 was made general foreman of the electrical department. In 1958, he was promoted to assistant superintendent of the department, the position he held when appointed to his new post.

Michael J. Amoroso recently joined Allegheny Ludlum Steel Corp. as a mechanical engineer in the steel company's General Engineering Division. He formerly was a design engineer at Blaw-Knox Co.

John C. Smaltz has resigned as president, McKiernan–Terry Corp. He will devote his time to the engineering and research work of the corporation as its consulting engineer. **Carl W. Shattuck,** who was formerly first vice president, was elected president to succeed Mr. Smaltz. Mr. Shattuck has been connected with the corporation for 30 years. **Herbert G. Dillon** succeeds Mr. Shattuck as first vice president, and remains in charge of the company's Mead-Morrison Division at Harrison, N. J. **Frank Hamilton, Jr.,** a newly-elected vice president, will assume Mr. Shattuck's previous responsibility as general manager of the company's Dover, N. J., works.

J. Harry Reed, formerly sales manager, has been named vice president—sales of The Youngstown Foundry & Machine Co. Starting 12 years ago in the company's Roll Department, he has had a wide range of experience in production and sales.

J. G. Wills has been named manager—manufacturing of Blaw-Knox Co.'s Equipment Division. He succeeds **T. J. Joyce** who has resigned. An employe of Blaw-Knox for 16 years until 1951, Mr. Wills was employed in manufacturing management positions by U. S. Hoffman Machinery Co. and Crown Cork and Seal Co., before rejoining Blaw-Knox as assistant works manager in 1957.

William B. Nicholson has been appointed a vice president of Linde Co., division of Union Carbide Corp. At the same time, **Robert F. Flood** was named vice president—gas products.

Mr. Nicholson joined Union Carbide in 1935 as an engineer in the Linde development laboratory at Newark, N. J. In 1936 he moved to New York as service engineer in the eastern division of the company. He remained in Linde's sales organization until 1944 working out of New York, Pittsburgh and Cleveland. At the end of 1944 he returned to the Newark laboratory as assistant manager, becoming manager the following year. In 1954 he was transferred to New York as assistant manager of development and engineering service for the company, becoming manager of development in 1956. He was made vice president—gas products of Linde in 1957.

Mr. Flood became associated with Union Carbide in 1935 as an engineer at the development laboratory of Linde in Newark. The following year he was transferred to Chicago as service engineer, later to the Detroit district office as assistant manager and then to Cleveland as assistant manager. Mr. Flood was made district manager at Indianapolis in 1949 and, in 1953, came to New York as assistant sales manager, apparatus. He moved up to the position of general manager—Flame-Plating department in 1955, and became general manager—new products in 1958.

William H. Wachter has been promoted to director of plant engineering, Jones & Laughlin Steel Corp., and will direct the activities of J&L's works and resident engineers as well as supervise contracts and civil engineering matters at staff level. He formerly was assistant chief engineer—Plants and Construction. **Stephen Vajda** has been promoted to staff process design engineer. He formerly was a special engineer. His new position will include increased responsibilities in chemical engineering. Mr. Wachter has been a J&L employe since 1923 when he joined the corporation as a detailer in the Engineering Department. He since has held positions as designer, squad leader, structural engineer, assistant works engineer and works engineer at J&L's Pittsburgh Plant, and assistant chief engineer. Mr. Vajda joined J&L in 1948 as a detailer in the Pittsburgh Works' Engineering Department. He has held positions as a designer and combustion engineer at the Pittsburgh Works, and was promoted to staff engineer in the office of the chief engineer in 1952. He was named a special engineer in 1956.

George A. Kaufman has been retained as a consultant to the chief engineer at Jones & Laughlin Steel Corp. Mr. Kaufman formerly was assistant chief engineer—Engineering and Planning. He was to retire last month.

F. J. ZUPANCIC

M. J. AMOROSO

C. W. SHATTUCK

J. H. REED

J. A. ACKERMANN

W. D. FULLERTON

F. C. HOHENSTEIN

SCHAEFFER SPECHT

He has been a J&L employe since 1920 when he joined the corporation as an electrical engineering assistant. He was appointed an electrical engineer in 1935, chief electrical engineer in 1940 and assistant chief engineer—Engineering and Planning in 1956. Prior to his J&L service, he was employed at the Homestead Steel Works of United States Steel Corp.

Joseph A. Ackermann has been named sales manager and **John A. Draxler,** chief engineer, of The Elwell-Parker Electric Co. Mr. Ackermann, for the past three years, has been Elwell-Parker's chief engineer. He first joined the company in 1923 as a draftsman, was subsequently named chief draftsman, and was appointed assistant chief engineer in 1947. Mr. Draxler, formerly assistant chief engineer, first joined the company in 1937, also as a draftsman. In 1946, he was appointed manager of the Field Service Engineering Department. He was named assistant chief engineer in addition to this post in 1954.

William D. Fullerton has been appointed assistant general manager, and **William L. Fabianic,** director of research, at Refractories Division, H. K. Porter Co., Inc. Mr. Fullerton, who joined Porter in 1957, was assistant to the president prior to his appointment. Mr. Fabianic, who was recently vice president and director of research for Laclede-Christy Co., which was consolidated into H. K. Porter's Refractories Division, will now handle research for all refractory products.

F. C. Hohenstein has been announced as Chicago district manager for Elliott Co., succeeding **W. E. Widau,** who is now midwestern regional manager. Mr. Hohenstein was in the heat transfer application engineering department, in Jeannette, Pa., for two years before being assigned as a field engineer in the Chicago office in 1948.

Schaeffer Specht has been appointed to the sales staff of Buell Engineering Co., Inc. He was formerly assistant sales manager of Research—Cottrell, Inc.

John H. Miller has been appointed general plant engineer for Heppenstall Co. Mr. Miller started with the company in 1955 as chief engineer for its Indianapolis, Ind., plant. Previously he had served as an engineer with the Taylor-Wilson Manufacturing Co.

Robert M. Waples was elected chairman of the board, The Garlock Packing Co. He formerly served as president of the firm. Mr. Waples succeeds **George L. Abbott** who has retired as board chairman, but will remain as a director and chairman of the executive committee. **A. J. McMullen,** a vice president, has been named president and principal executive and administrative officer of the company. He was elected a director and vice president of Garlock in 1955. Mr. Abbott joined Garlock in 1911 and subsequently became a director, general manager and vice president. He was named president in 1928, and continued in that capacity until 1955 when he was elected chairman and chief executive officer.

Thomas F. Read has been appointed manager of engineering and estimating for the Montebello Fabricating Division plant of Kaiser Steel Corp. Before joining Kaiser, Mr. Read served as production manager and assistant general superintendent of the Florida Division of the Alliance Machine Co. and Alliance Structural Co.

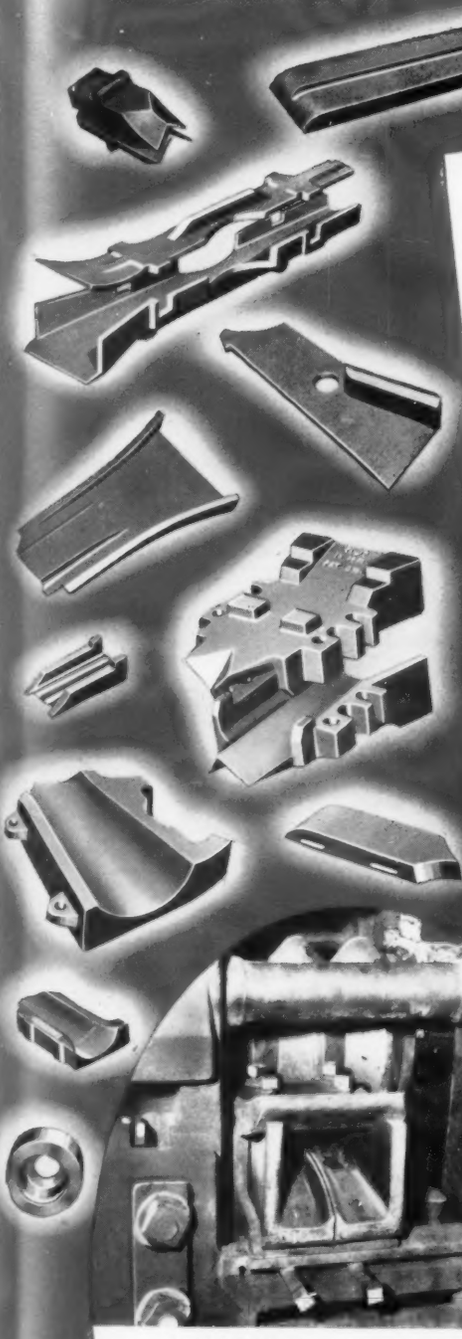
Lawrence M. Roberts has been elected senior vice president, Research—Cottrell, Inc. At the same time, three sales appointments for the firm were announced: **William H. Blessing,** New York district sales manager; **Richard H. Betchley,** San Francisco sales manager; and **Robert L. Sferra,** sales engineer for the San Francisco district.

Edwin J. Bernard was appointed project engineer, Loftus Engineering Corp. He formerly was associated with Reynolds Metals Co. and the Aluminum Co. of America.

E. P. Best has been appointed director of metallurgy and research, and **T. D. Bonner,** chief wrought iron metallurgist for A. M. Byers Co. Formerly chief metallurgist, Mr. Best now heads up the metallurgical, chemical and research departments. He has been with Byers since 1917 in various metallurgical positions at the Ambridge and South Side plants. Mr. Bonner has been with Byers almost four years. He was formerly employed by United States Steel Corp. as a process engineer.

John N. Moore, Jr., has been appointed manager of the southwestern district of the Metal Products Division, Koppers Co., Inc. He joined Koppers in 1952 and, after initial training, was assigned to the Chicago, Ill.,

TRANTINYL GUIDES
THE STEEL INDUSTRY



Steel Producers amazed at HIGH TONNAGE rolled with TRANTINYL GUIDES

Entry Guides

Delivery Guides

Two pair of angle guides, still in serviceable condition after long usage

These entry and delivery guides on 12" mill were photographed in a midwest steel plant after rolling unusually high tonnage. Guides showed no noticeable signs of wear and proved again the outstanding durability of "TRANTINYL." If you have not yet tested "Trantinyl" guides to your own satisfaction, why not try them now.

12" Mill showing Entry Guides

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century. Rolling more than 100,000 tons over a single pair of guides has been recorded.

Guides for Rolling Mills • Tube Mills
Straightening Machine Guides
Heat-Resisting "Trantinyl" Cast-to-Shape

Youngstown Alloy Casting Corporation

Youngstown, Ohio

office as a sales engineer. In 1955 he was appointed manager of the division's Cleveland, Ohio, office, the position he held prior to his latest promotion.

S. J. Rebholz has retired as assistant sales manager, Mesta Machine Co. A veteran of over 45 years' service with Mesta, Mr. Rebholz began his career as a draftsman for Jones and Laughlin Steel Corp. in 1906. He served as a draftsman and sales engineer at Mesta from 1913 to 1931 when he was promoted to assistant sales manager, the position he held for over 27 years.

John L. Austin has been appointed sales manager of Gem Clay Forming, Inc. Mr. Austin was formerly vice president of Keagler-Austin Co. He also served with Robinson Clay Products.

Sydney Buckley, president of Shepard Niles Crane & Hoist Corp., has retired after 60 years of service with the company, and becomes chairman of the board of directors. Mr. Buckley joined the Crane Division of Niles-Bement-Pond in 1898 and became, successively, chief engineer and president of this Division. In 1929 he became vice president of the merger which resulted in the formation of the Shepard Niles Crane & Hoist Corp. **John S. Jackson,** formerly vice president and general sales manager, has been appointed president and general manager. **Herbert W. Gledhill, Jr.,** becomes vice president and general sales manager.

Ralph W. Skerratt, Jr., has been named president and general manager of the Falcon Foundry Co. In addition, **John C. Lopatta** was appointed as vice president. Mr. Skerratt was formerly executive vice president and Mr. Lopatta was operating vice president.

John N. Ludwig, Jr., has been appointed supervisor of metallurgical services of the International Nickel Co., Inc. He was formerly associated with the Electro Metallurgical Co., division of Union Carbide Corp., for 21 years.

John Manning has been appointed West Coast sales engineer on rolls, mill machinery and steel plant equipment, for Blaw-Knox Co. From 1951 through 1958, Mr. Manning was a rolling mill consultant for various companies in France, Belgium, Australia and Japan. He was formerly associated with Bethlehem Steel Co., Lackawanna, N. Y., and with the Columbia-Geneva Steel Division of United States Steel Corp., Provo, Utah.

Fred Van Camp was appointed works manager, Buffalo Steel Corp., Tonawanda, N. Y. Mr. Van Camp was formerly general plant night superintendent of the Wickwire-Spencer Steel Division of Colorado Fuel and Iron Corp.

Homer M. Lloyd has been named project manager at the Rust Engineering Co. and will be in charge of projects involving steam and power plants, metallurgical plants and blast furnace facilities. Mr. Lloyd joined Rust in 1952 as a project engineer. **Harry R. Lawson** has been named project manager at Rust Engineering's office in Birmingham, Ala., and is in charge of projects involving steel mills. Mr. Lawson joined Rust Engineering in 1953 as a design engineer. He later served several years as project engineer on major design jobs in metallurgical and chemical fields.

Frank J. Hogg has been elected vice president in charge of engineering for the David W. Murray Co. In his new capacity, Mr. Hogg will direct all engineering activities for the Cleveland, Pittsburgh and Toledo offices. Mr. Hogg joined the Toledo branch of the company in 1948. After being transferred to the main office of the firm in Cleveland, he was promoted to chief engineer in 1956.

James P. Clair has been appointed to the Jones & Laughlin Steel Corp.'s technical services staff as a metallurgical contact engineer. He was first employed by J&L in 1948 as a member of the Pittsburgh Works Metallurgical Department.

Ben T. Bartlett has been appointed district manager of the Okonite Co.'s Syracuse, N. Y., office. Mr. Bartlett formerly served as sales engineer at the company's Cincinnati, Ohio, office.

Robert W. Pressing has been appointed general manager, New Products Department, Linde Co., Division of Union Carbide Corp. He had formerly been manager of Molecular Sieves Production and Development at Linde Co., Tonawanda, N. Y.

J. A. Donnelly has been appointed chief engineer and **C. K. Buell, Jr.,** has been named plant manager of Fort Pitt Bridge Works. Mr. Donnelly replaces **V. L. Smith,** who retired after 38 years in the company's Engineering Department, the last four years serving as chief engineer. Mr. Donnelly had been plant manager for the structural steel fabricator and erector since 1955, and prior to that chief draftsman. Previously Mr. Buell had been assistant to the chief engineer.

Randolph R. Gustafson has been assigned as a field service engineer for A. M. Byers Co. Mr. Gustafson was formerly associated with Rust Engineering Co., Penn Metal Co., Inc., and Paul Smith Construction Co. and Mann Construction Co.

Walter F. Kaufman, formerly chief rope engineer for the Wickwire Spencer Steel Division, Colorado Fuel and Iron Corp., has joined the Paulsen-Webber Cordage Corp., Wire Rope Division, as vice president in charge of manufacturing at their Sunbury, Pa., mill.

Albert L. Fairley, Jr., has been appointed president of Dominion Steel and Coal Corp. Limited. Two other senior appointments were also announced: **Crawford Gordon, Jr.,** was named chairman of the board, and **Allan C. MacDonald,** vice chairman and chairman of the executive committee. Mr. Fairley, formerly executive vice president, succeeds Mr. Gordon, who is also president of the parent A. V. Roe Canada Limited.

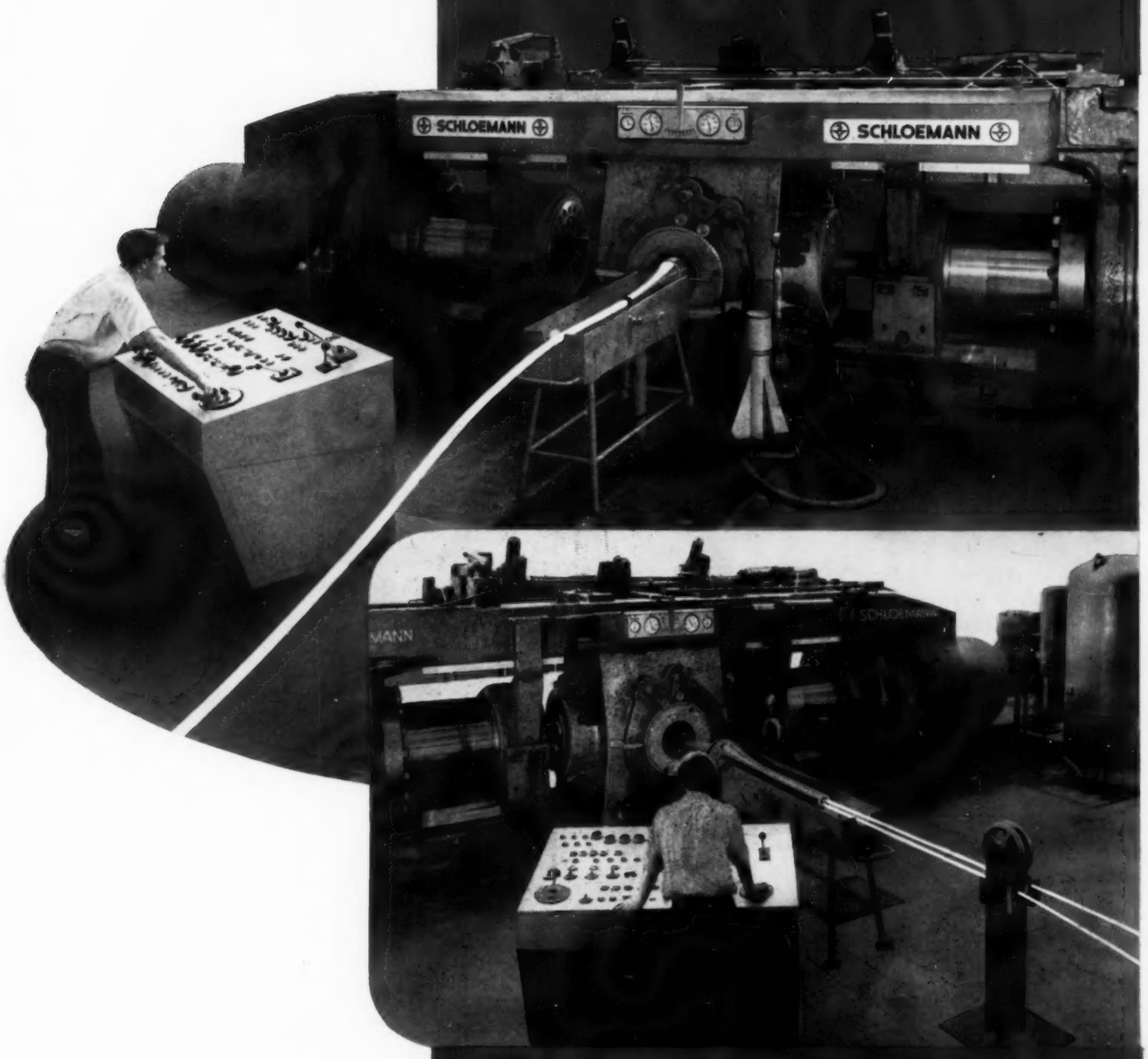
Vincent E. Oswald, president of Electric Manufacturing and Repair Co., has been elected chairman of the Chandeysson Electric Co.

James L. Daniell has been elected president of Green River Steel Co., subsidiary of Jessop Steel Co. Mr. Daniell has been executive assistant to the president of Jessop.

Paul J. Reeves has been appointed vice president in charge of sales for the Timken Roller Bearing Co. He succeeds **W. B. Moore,** who retired March 1.

SCHLOEMANN

Aluminium Cable Sheathing Press



Double-acting horizontal 1,760 ton aluminum cable sheathing press. Upper: Sheathing power cable. Lower: Two-strand extrusion of wire rod.

Cable sheaths from 3/16 to 4 inches outside diameter and with any desired wall thickness over .008 inch can be extruded onto heat-sensitive cable cores of any length. The extrusion program may be extended by the production of wire rods, tubes and sections. Full automation of the operating cycle assures uniformly high quality of the products. SCHLOEMANN aluminum cable sheathing presses are operating in the U.S.A., Germany and other countries; main design features are protected by patents. *For detailed information send for bulletin P2/322.*

FELLER ENGINEERING COMPANY 1160 Empire Building, Pittsburgh 22, Pa.

HOT AND COLD ROLLING MILLS · COUNTERBLOW HAMMERS · HYDRAULIC PRESSES

New

Link-Type HINGE ALIGNMENT DEVICE

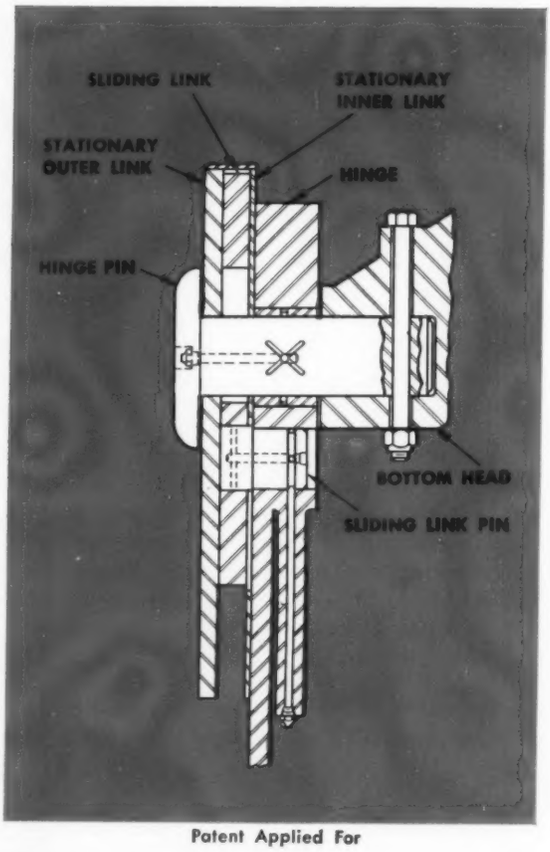
available on Mead-Morrison Grab Buckets

...eliminates hinge gears

When non-crushable material gets caught in a conventional grab bucket gear-type alignment device, it means trouble . . . jammed and broken teeth.

The exclusive link-type hinge alignment device developed by Mead-Morrison *eliminates* this trouble. It operates by the interaction of a linkage of steel plates instead of the vulnerable gear teeth of conventional alignment devices. The mechanism is fabricated entirely of high tensile alloy steel. In addition, it has a much larger bearing surface than the ordinary gear-tooth construction, is entirely enclosed and easily lubricated. The result . . . less lubrication problem . . . less maintenance expense.

Write for free working model of this device.



Patent Applied For

MEAD-MORRISON

Division of McKIERNAN-TERRY CORPORATION

HARRISON, NEW JERSEY

MK323

Mr. Reeves was succeeded as director of sales by **Robert G. Wingerter.**

Mr. Reeves joined Timken in 1929 as a sales engineer and was made district manager of the Industrial Division's California branch in 1932. He became sales promotion manager in 1940 and from 1941 to 1943 acted as manager of the Priorities Department. He was promoted to advertising manager in 1944 and director of sales in 1951.

Mr. Wingerter joined Timken in 1938 as a sales trainee in the Industrial Division in Canton, Ohio, and two years later became an industrial design engineer. He became assistant chief engineer of the Industrial Division in 1943 and transferred to the Detroit, Mich., office of the Automotive Division as sales engineer in 1944. He was made assistant general manager of that division in 1951 and general manager in 1955.

G. W. Gould has been appointed general superintendent of Midwest Steel Corp., the new plant which National Steel Corp. will build in northwestern Indiana in the Chicago metropolitan area. Prior to being advanced to his new post, Mr. Gould was assistant general superintendent of Weirton Steel Co., having been appointed to that position in 1955. He began his employment with Weirton Steel in 1929 in the office of the Tin Mill Department, and advanced through a series of positions to be named night superintendent of the department in 1940. In 1944 he was promoted to assistant manager of the Tin Mill, in 1953 was named manager, then in 1955 was promoted to assistant general superintendent in the Weirton Steel operating department.

Arch Miller, Jr., succeeds Mr. Gould as assistant general superintendent, Weirton Steel Co., advancing to that position from manager of the Tin Mill Department. **George E. Hugus** has been promoted from assistant manager to manager, succeeding Mr. Miller; and **Ralph W. Harris** advanced from night superintendent to assistant manager, succeeding Mr. Hugus. Mr. Miller began his employment with Weirton Steel in 1931 in the Metallurgical Department. In 1944 he was named night superintendent in the Tin Mill Department, advanced to assistant to the manager in 1950, was named assistant manager in 1953 and was promoted to manager in 1955. Mr. Hugus began his employment with Weirton Steel in 1941 in the Metallurgical Department, in 1952 was named night superintendent of the Tin Mill and in 1955 was advanced to assistant manager. Mr. Harris joined Weirton in 1948 in the Metallurgical Department, in 1952 was named assistant senior metallurgist and in 1955 was transferred to the Tin Mill Department as night superintendent.

James Mitchell has been appointed district sales manager in the Colorado area by Harbison-Walker Refractories Co. He will make his headquarters at Canon City, Colo., and will be active in all of Colorado and Wyoming and in parts of South Dakota, Nebraska, Kansas and New Mexico. Mr. Mitchell has been with Harbison-Walker since 1946, most recently in the Philadelphia sales district.

Gordon S. Rogers has been advanced to assistant director, production planning, American Steel & Wire Division, United States Steel Corp. Succeeding Mr. Rogers as administrative assistant in the vice president's office, is **David J. George.**

Mr. Rogers began his career with the Wire Division as an industrial engineer at the Worcester, Mass., cable works. In 1946 he was named as senior planning engineer in the Cleveland office. Mr. Rogers became office manager for the vice president—operations in 1949. He was promoted to administrative assistant in 1955.

Mr. George began his career with the Wire Division at the Donora Works in 1940. He became assistant industrial engineer and was advanced to cost engineer in 1947. He became works industrial engineer at the Rankin Works in 1951 and returned to American Steel & Wire's general office in 1957 as staff industrial engineer, the position he held until his present appointment.

William K. Smith has been named assistant manager of systems and procedures, National Steel Corp. Mr. Smith was formerly with the Steel Division of Ford Motor Co. where he was supervisor of systems and procedures. Prior to his ten year service with Ford, Mr. Smith was employed as a senior procedure analyst for the American Steel and Wire Division of United States Steel Corp., and before that was tabulating chief at the Irvin Works of U. S. Steel.

Obituary

Van Winkle Todd, 66, chairman of the board of directors of Hanson-Van Winkle-Munning Co., died January 15.

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Want to eliminate your acid pickling problems?
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Then investigate our new BLAST CLEANING CONSULTING SERVICE.
The steel industry is considering mechanical blast cleaning as a proven process providing positive answers to these questions. More than 8 basic applications of the process now in operation qualifies its adoption.
The logical FIRST STEP is a complete analysis covering your operation, and warranted by 14 years experience in the development and application of the process.
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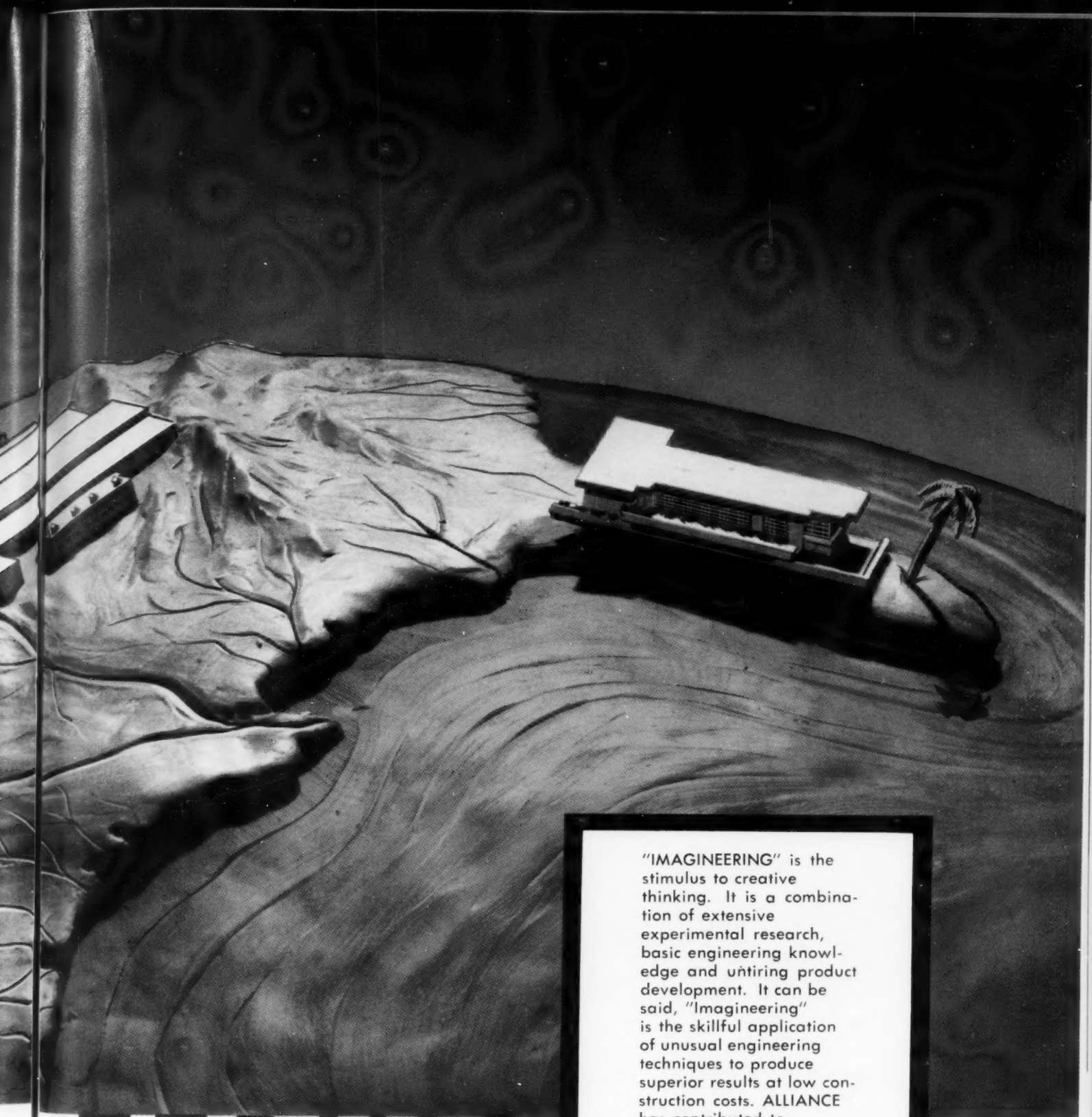

EERING

"IMAGINEERING" is the stimulus to creative thinking. It is a combination of extensive experimental research, basic engineering knowledge and untiring product development. It can be said, "Imagineering" is the skillful application of unusual engineering techniques to produce superior results at low construction costs. ALLIANCE has contributed to industrial development around the world. With "Imagineering" . . .

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Car Dumpers * Special Mill Equipment * Ore & Coal Bridges * Loading & Unloading Towers * Forging Manipulators * Forging Cranes * Power House & Dam Cranes * Dock & Pier Handling Equipment * Research, Development & Engineering Service * Licensees & Manufacturing Facilities

Inspection of 75-foot Salem Rotary Hearth Furnace at The Timken Roller Bearing Company plant at Canton, Ohio.

Rotary hearth roof of B&W IFB gives nine years of service at the Timken Company

Installed as a replacement for a super-duty firebrick sprung arch, over 35,000 B&W Insulating Firebrick were used in the roof of this rotary hearth furnace. Since installation nine years ago, just 300 9″ equivalents have been used for maintenance—less than 1% replacement!

Throughout this period the furnace has been operated at temperatures ranging from 2100 F to 2300 F on a continuous 6-day cycle at an average output of 20 tons per hour.

In addition to long service life, light-weight B&W Insulating Firebrick provide high fuel savings because of their low heat flow and heat storage. Light-weight IFB also simplify original furnace construction...make maintenance and patching easier.

For more information on long-lasting, cost cutting B&W Insulating Firebrick, consult your B&W Refractories Representative or send for Bulletin R-2-H.

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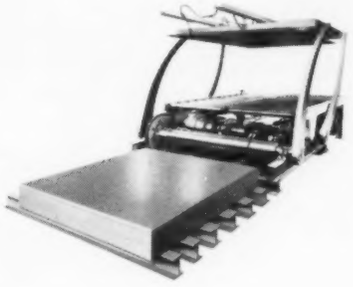
Equipment News...

PLATE-SHEET FEEDER

△ The new plate and sheet feeder introduced by The Herr Equipment Corp. will pick up sheets or plates from a stack, automatically, one at a time. It places the plate or sheet on a table of driven rolls, alines it accurately and automatically with the dies, and feeds it into the press. Operation can be either continuous at a fixed cycle, or intermittently as the press operator directs.

The machine eliminates the costly and dangerous practice of prying plates loose from a stack manually, attaching hooks or grabs, and feeding the plate into a press from a roller table. It obsoletes a "gang" operation, and enables one man to do the entire job quickly, accurately and at low cost.

As illustrated, the equipment consists of a table of "I" beams, mounted transversely, and provided with adjustable side guides, to assist the crane operator in locating the stack of plates or sheets in approximate alinement with the machine; and permitting easy removal of banding, the grab, etc. Four pivoting arms mounted in



pairs, two on each side of the machine, support a vacuum lifting mechanism—the frame being fitted with a probe, to adjust the swing, to the diminishing height of the stack. The vacuum mechanism picks up one plate or sheet at a time, and carries it, always in horizontal plane, to a position about an inch above the driven roll feed table. When the vacuum is released, the plate or sheet drops down onto the feed table, is immediately and automatically alined with the dies, by side guide rollers, and is then advanced into the press.

After releasing its plate the pivoting arms and vacuum mechanism immediately swing back, pick up the next plate, return and either drop the plate onto the feed table automatically (i.e., continuous operation), or hold it above the feed table until the operator presses a vacuum release switch (i.e., intermittent operation). Thus, although there is only one operator, no downtime is incurred. A sheet or plate is always ready to be fed into the press until the feed stack is exhausted.

The company reports that the present machine will handle sheets or plates from 3½ ft minimum to 8 ft maximum width; 7½ ft minimum to 12 ft maximum length; weighing up to about 600 lb each; on a one minute cycle. The equipment requires about 10½ ft x 28 ft of floor space, and only about 10 ft of head room. Variations from this standard design are available to meet other requirements. The unit could also be used as a stacker.

MOBILE LADLE FEEDER ADDS FERROMANGANESE

Ferromanganese fed by a mobile ladle additions feeder goes into the ladle during tapping of a 200-ton electric furnace. Designed and built by Blaw-Knox Co., the 12-cu ft capacity feeder is powered by a gasoline platform truck. The pivoted discharge chute is retractable. The feeder makes specific quantity additions of ferro alloys to ladles, at controlled rates of feed.

DUPLEX RECORDER

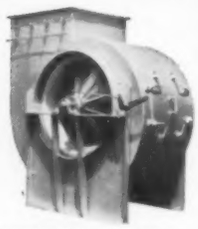
△ A compact, general-purpose recorder for plotting two related electrical quantities side-by-side on a single chart has been announced by General Electric Co.'s Instrument Department.

A member of the company's CH recorder family, the unit is known as the CH-37 duplex recorder.

The duplex brings new convenience to utility, steel mill, laboratory and other measurement applications where accurate data comparison is important.

The double record on a single roll permits faster reading and helps eliminate possible reading errors associated with matching separate

WHIRLEX
Shop Assembled
DUST COLLECTORS . . .



WHIRLEX FORCED DRAFT FANS are designed for heavy duty service in all types of boiler applications. Airfoil bladed impeller provides maximum static efficiency.

- - - Eliminate Costly Field Assembly

Whirlex dust collectors are designed to provide maximum collection efficiency for each specific type of application. The unit is then fabricated and completely shop assembled and need only be set in place and the hoppers bolted on at the installation site. Each Whirlex unit is rigidly inspected before it leaves the shop, assuring a completely "gas-tight" installation.

More specific information is available upon request.

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CORPORATION
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Dust Collectors • Induced Draft Fans
Forced Draft Fans • Exhaust Fans
Self Supporting Stacks • Duct Work

FLY ASH WHIRLEX ARRESTOR

charts when correlating quantities such as watts and vars, volts and frequency, ro wind direction and speed.

Although containing two separate, flexible recording mechanisms, the CH-37 occupies ⅓ less space than is required for a pair of synchronously operated CH-1 single element recorders performing the same function.

Housed in a 15-in. wide by 16-in. high cast aluminum case containing extra hand space for easy maintenance, the CH-37 is designed for semi-flush panel mounting.

The low burden, fast response recording elements trace on two 4-in. calibrated charts printed on a 10-in. wide record roll.

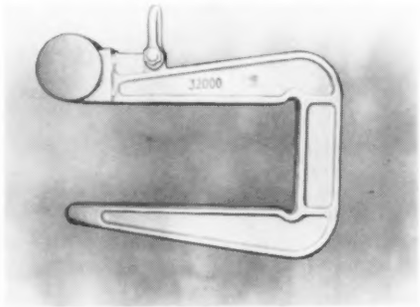
The recorder incorporates all the popular features of the CH line including throw-away inkwell, gasket-sealed door with key-operated lock, multiple chart speeds, chart supply indicator and a fluorescent-lighted chart face for easy reading.

The Duplex is available with a complete set of rate gears and either a single speed synchronous motor giving 11 chart speeds ranging from ¼ to 30 in. per hour or a double speed synchronous motor offering 28 speeds from ¼ in. per hour to 120 in. per minute.

COIL HOOK

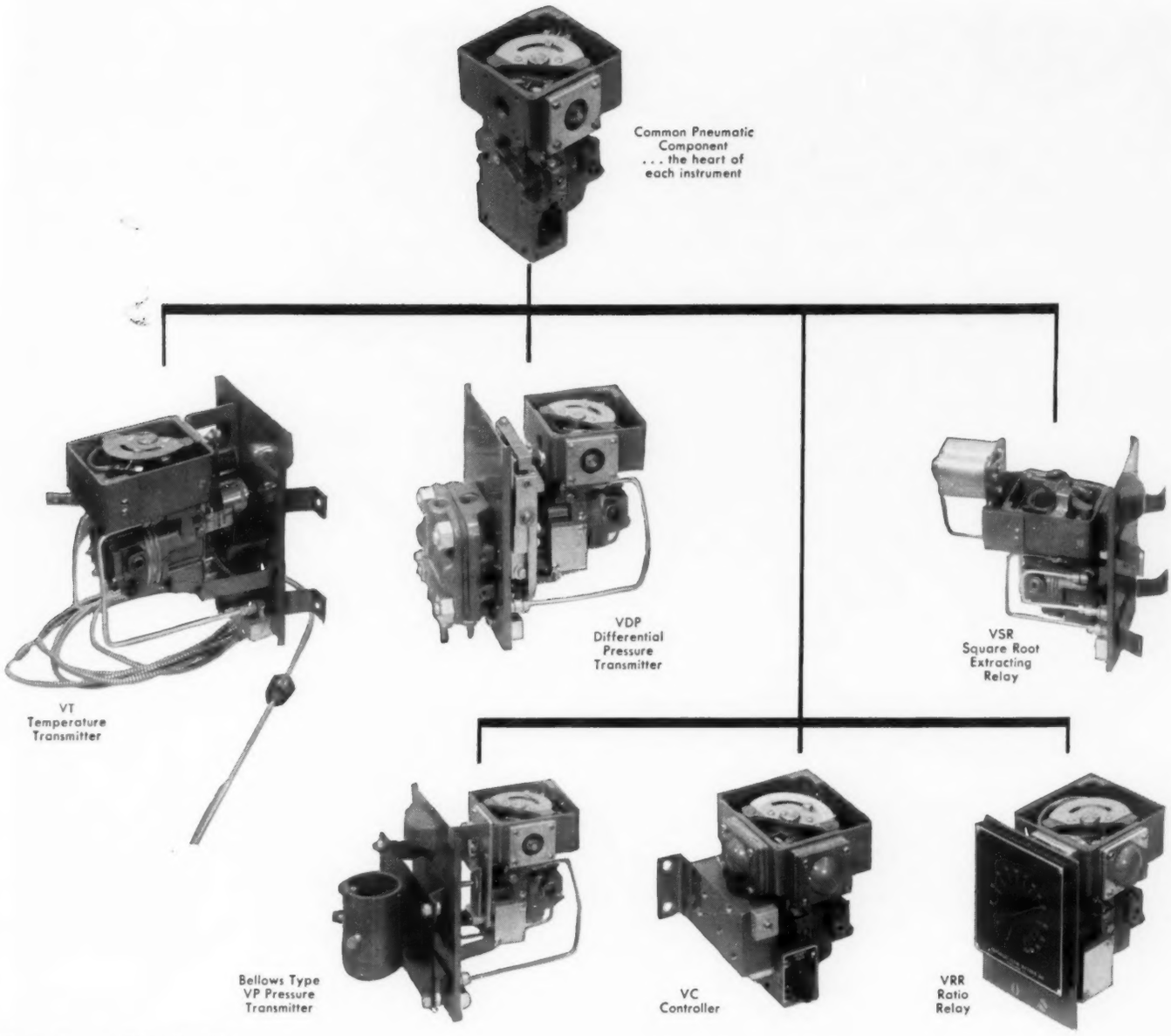
△ A new cast steel hook, a recent development of Mansaver Industries, Inc., is now available to the metal industry for handling coils.

The hook is pre-balanced, making it easy for the operator to guide the member into the coil inside diameter. It is designed for all horizontal



coil handling, including carrying to and from the slitters and coil reels, loading, storing, and shipping.

All sections of this heavy-duty coil hook which are under heavy stress are x-rayed and magnafluxed to make certain there are no hidden defects. The hook illustrated


Common Pneumatic Component . . . the heart of each instrument
VT Temperature Transmitter
VDP Differential Pressure Transmitter
VSR Square Root Extracting Relay
Bellows Type VP Pressure Transmitter
VC Controller
VRR Ratio Relay

Rockwell-Built

Republic Vector Series Instruments

serve any process, cut costs too!

You can save substantial money when your control systems are based on Republic's Null-Balance Vector instruments. Each has as its "heart" an identical pneumatic component, with obvious advantages. Among these are interchange of parts, even among instruments performing entirely different functions. Besides involving a minimum spare parts inventory, this feature greatly simplifies personnel training.

Components shown demonstrate the depth of the Republic line. Differential pressure transmitters with 20-to-1 range adjustment . . . temperature transmitters with 10-to-1 range adjustment . . . pressure transmitters of ±.5% accuracy. We have ratio, totalizing, multiplying, squaring and square root extracting relays. Our all-purpose controllers feature proportional band adjustment of 2% to 500% and reset adjustment from 0.1 to 50 repeats per minute.

The Republic Engineer in your area will be glad to work with you on any control or measurement problem. Sales offices in principal cities throughout the United States and Canada. Call or write—with no obligation, of course.

REPUBLIC FLOW METERS CO.

Subsidiary of ROCKWELL MANUFACTURING COMPANY
2240 DIVERSEY PARKWAY CHICAGO 47, ILLINOIS
In Canada: Republic Flow Meters Canada, Ltd.—Toronto
Manufacturers of electronic and pneumatic instrument and control systems for utility, process and industrial applications.

APPLETON "YS" REELITES®

help you "Hoist" profits on monorail operations

APPLETON "YS" SERIES REELITES HAVE SUPERIOR FEATURES

- Feeds and Retrieves power cord in any direction (335° swivel) to double track coverage.
- Enclosed copper graphite and collector rings eliminate dangers of exposed collectors, trolleys, etc.
- Neoprene covered cables seal out moisture, oil, chemical fumes.
- Easy to maintain. Power spring, brushes, etc., removed through outer cover. Solderless cord connections, and oilless bearings.
- A heavy duty hoist reel . . . Rating: 10 or 15 amp., 550 v., AC: 250 v., DC: 2, 3, or 4 cond.—16 and 14 gauge wire.

You can take a long step towards automation in your plant by installing any number of APPLETON "YS" Series Reelites to expedite materials handling via monorail systems. These quality Reelites are backed by APPLETON'S years of experience in the field and offer you all the benefits of rugged construction and low-maintenance dependability. Write for complete information today . . . there is a style and model APPLETON "YS" Series REELITE for most applications in your plant.

APPLETON ELECTRIC COMPANY
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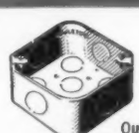
APPLETON ELECTRIC PRODUCTS®

Also Manufacturers of:

Malleable Iron Unilets

Industrial Lighting Equipment

"ST" Series Connectors


Outlet Boxes

Rely on APPLETON *. . . The Standard for Better Wiring*

was built for handling a 32,000-lb load, but it can be supplied in almost any capacity, with 20,000 lb a practical minimum.

LOCK-OFF UNIT

△ Square D Co. has announced a new lock-off device which they have incorporated in their NEMA 4 and NEMA 12 enclosures for manual starters. By sliding a stainless steel plate over the "Start" button and inserting a padlock, the starter can be locked in the "Off" position.

The pushbuttons are recessed to prevent accidental operation.

The new NEMA 4 watertight and NEMA 12 industrial enclosures are designed for Square D Types B and C integral horsepower manual starters. Silicon rubber boots over the pushbuttons prevent the entry of water, dust, or coolant. The "Start" and "Stop-Reset" buttons are made of anodized aluminum, and are inserted in the boots.

TAKE-UP FRAME

△ Lovejoy Flexible Coupling Co. has developed a new take-up frame that permits the use of any pillow block. One basic frame size accommodates all types—ball, roller or babbitted. The frame can be top or side mounted. This is accomplished simply by loosening a locknut, which permits swinging the flange connection either way.

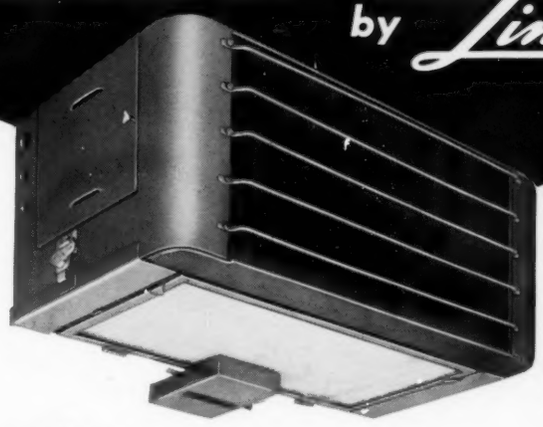
A large nut is mounted on both ends of the adjusting screw, each ending with a heavy steel rod pin. This permits easy disassembly and removal of all parts without special tools. All parts can be individually replaced.

The adjusting screw is enclosed for protection against dirt, contamination, etc., and thus requires far less attention than open mounted screws. However, when lubrication or cleaning is desired, a quickly removed face plate gives easy access for this purpose.

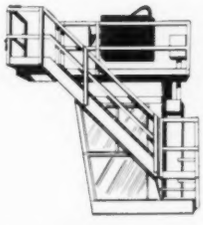
Known as the "Versa Mount," the frame is equally suitable for installation on new or old equipment. It is highly compact and ruggedly constructed, including heavy formed welded steel frame and large zinc-plated adjusting screw.

A wide range of sizes and travel lengths from 2 in. to 36 in. are available from stock. These will accommodate any type or make of pillow block from ½ in. to 2 7/16 in. In addition to take-up, the frame is also highly recommended for motor base, head shaft support and similar applications.

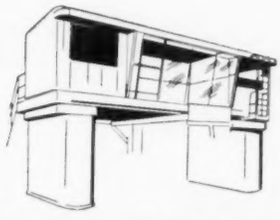
NEW CAB UNIT by Lintern



Ceiling Mounted Cab Unit



for Cabs and Pulpits



Mounts on Ceiling, Floor, or Wall

Smaller, more compact, lighter in weight — for mounting on ceiling, floor, or wall — this new Cab Unit sets a new record in crane cab and pulpit conditioning.

It contains many new features insuring economies in operation, more efficient service.

Now for the first time, for better temperature control, the Pilot Control is mounted *within the Cab Unit* — or may be mounted remotely.

Ask for new Bulletin AC-587 describing the many features and advantages of this outstanding product.

Larco, inc.
DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS
ROUTE 20, EAST • PAINESVILLE, OHIO

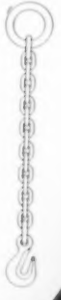
HERC-ALLOY

THE ORIGINAL ALLOY STEEL CHAIN

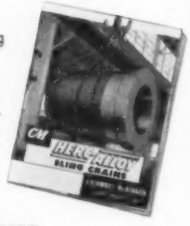
● Herc-Alloy is a special all-purpose chain with long-wearing properties and high resistance to impact loading.

● Herc-Alloy is sold in running lengths and in all types and sizes of sling chains assembled to customers' specifications.

● CM also produces a complete line of chain attachments and welded chain of all types including stainless steel and bronze.



● Write for literature covering Herc-Alloy Sling Chains, including helpful information on their assembly, care, use and inspection.



Hammerlok®

COUPLING LINKS

● Assemble or rebuild your own Herc-Alloy sling chains with all components furnished by your local distributor. Hammerlok is simple, safe, reusable. New Herc-Alloy assemblies can now be ordered with welded or Hammerlok Coupling Links as desired.

CM HOISTS AND CHAIN

CALL YOUR CM CHAIN DISTRIBUTOR

COLUMBUS McKINNON

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Regional Offices: NEW YORK • CHICAGO • CLEVELAND

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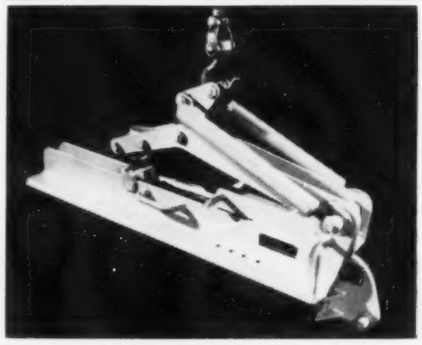
Herc-Alloy®

COIL TONGS



Manually adjusted vertical coil tongs developed by Heppenstall Co. for use where headroom is extremely limited. When latched open to receive a load, as shown in picture, tongs are only 17 in. high and height is increased only 7 in. with clevis and levers fully extended while lifting a load.

▲

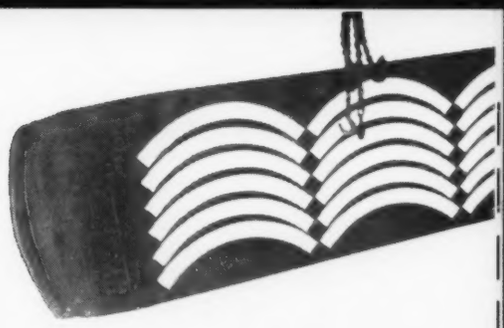
STRAIGHTENER

△ Sutton Engineering Co. offers a new, two-plane straightening machine for high-speed straightening of steel and nonferrous flats and shapes such as squares, hexagons, angles and other similar sections.

Known as the 2L shape straightener, the new machine will accurately straighten squares from ¼ in. to 1½ in., hexagons from ¼ in. to 1¾ in. and flats up to 2½ in. x ½ in. at high production speeds.

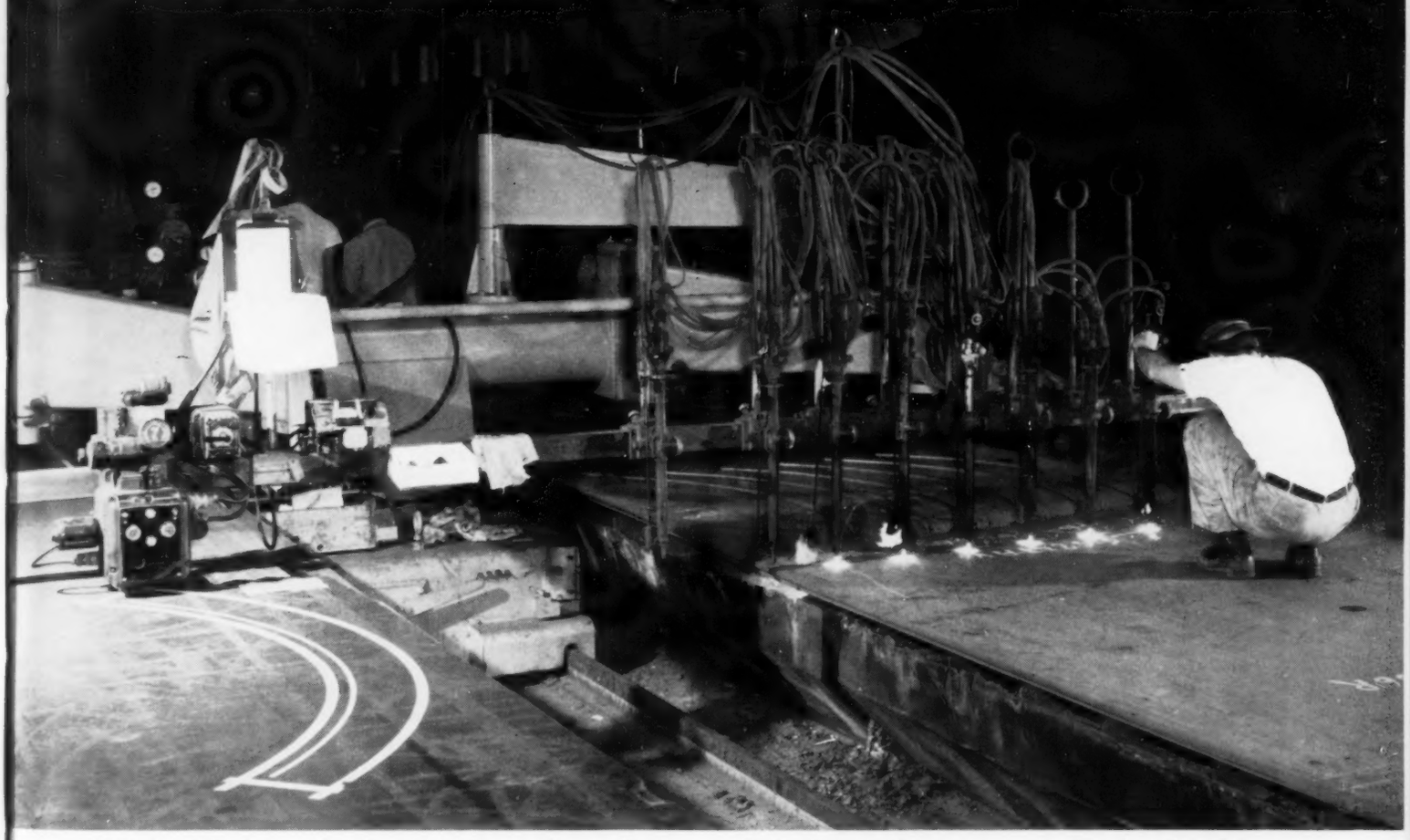
Featured in the machine design are extremely large roll shafts on very close centers. This development permits the removal of short hooks, waves and kinks and eliminates the need for intermediate guide rolls. New, specially designed unitized shaft construction permits rapid shaft removal for ease of maintenance. Anti-friction bearings are used throughout.

Perfect alinement of the roll passes can be accomplished quickly. The vertical shaft unit is adjustable up and down and the horizontal shaft unit is adjustable laterally to permit complete alinement of roll grooves in both units. Roll change is simple and rapid. All rolls are overhung and all adjustments necessary for straightening pressure or size changes are readily accessible to the operator. Spring loaded pinch rolls can be supplied at the entry end of each unit, if desired. It can be built in all sizes, and variations in design for both horizontal or vertical single-plane use are available.



With Airco's Multiple-Torch Flame Cutting Equipment...

MACHINE QUALITY CUTS



Whether it is the warehousing of steel parts for supply to metal-fabricators, or the production of parts by fabricators for assemblies and end products, multiple-torch flame cutting today plays a role of growing importance in modern industry.

"Machine quality" means close-tolerance cuts with equipment such as Air Reduction's Travograph® (shown in action), just one item in Airco's extensive line. It means elimination of plate-edge preparation for close fit-up, reduced handling and reduced labor costs . . .

Quality cuts with Airco machines are obtainable on a wide range of steel thicknesses for an unlimited variety of shapes. For information about the Airco cutting equipment best suited for your job, call your nearest Airco District Office, or write for literature.

AIRCO®

Offices and dealers in most principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated
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AT THE FRONTIERS OF PROGRESS YOU'LL FIND AN AIR REDUCTION PRODUCT • Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** – Industrial gases, welding and cutting equipment • **AIRCO CHEMICAL** – vinyl acetate monomer, vinyl stearate, methyl butynol, methyl pentynol, and other acetylenic chemicals • **PURECO**–carbon dioxide–gaseous, welding grade CO_2, liquid, solid ("DRY-ICE") • **OHIO**–medical gases and hospital equipment • **NATIONAL CARBIDE**–pipeline acetylene and calcium carbide • **COLTON**–polyvinyl acetate, alcohols, and other synthetic resins.

STARTERS-COMBINATIONS

△ Crouse-Hinds Co. has announced a model change in explosion-proof and dust-ignition-proof Type EPC starters and combinations in seven in. and nine in. sizes. Model M59 is of all-aluminum construction. Design improvements give easier accessibility to devices, and facilitate installation and maintenance.

Mounted on a separate, replaceable frame that provides 3-point suspension, Model M59 assures effective water shedding for the entire body through the use of male body threads at the top, female threads at the bottom, and a skirted upper cover. Covers are provided with plugged openings for breather and drain.

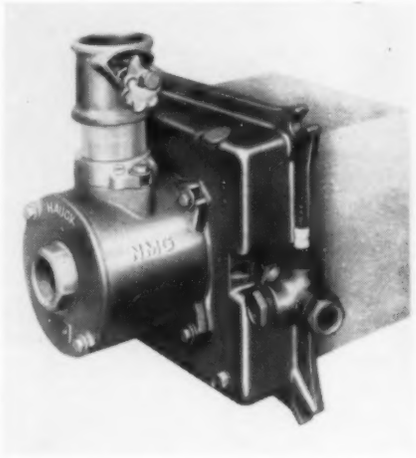
New covers provide easy access to internal devices, loosening quickly at pry points when pinch bar or screwdriver is used. Covers removed, the maintenance man can swing pivoted shoes to the side to remove pipe framework holding starter and breaker.

In addition to these features, Model M59 affords additional wiring space within a compact body—this compact design permits greater number of motor controls in any given area. Built-in pilot lights and triple padlocking of the circuit breaker are other new features.

MIX GAS BURNER

△ A new burner has been developed by Hauck Manufacturing Co. for heating processes requiring sealed-in firing with any commercial fuel gas.

The burner offers the application flexibility and advantage of firing with nozzle mixed gas over a wide



range of burner capacity, with exceptional flame stability. Lighting is positive at any burner setting on hot or cold furnaces, kilns or retorts. Combustion is more quiet than with premix burners. The high forward velocity of the combustion gases produces greater heat distribution. Since the air and gas mix at the burner outlet, there is no flashback. Proportioning mixers are eliminated. In this burner design, the gas streaming through the center is surrounded by a guide cylinder of air, igniting to produce a uniform fire in the burner tile, without causing excessive tile temperatures. Performance is satisfactory with normal or excess volume of air or gas. Excess air, for example, can be used from 300 per cent at 16 oz pressure to 1000 per cent at 4 oz or less pressure.

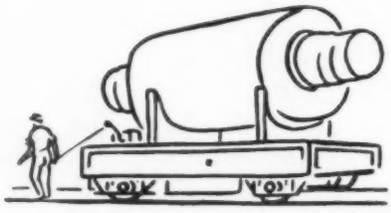
Because of its rugged construction and unusually high capacity ratings, installation is economical. A 2-in. nozzle mix burner may have the capacity of 3-in. burners of other makes. Cost saving is also reflected in piping, valves and controls.

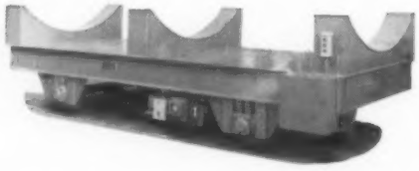
CUSTOM DESIGNED

for

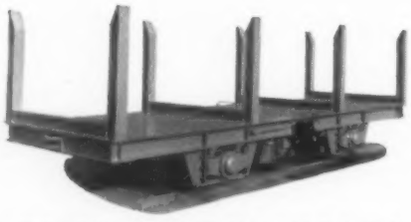
payload

efficiency





20-Ton Storage Battery with Cradle for Pipe



40-Ton Safety-Type Walk-Along with Stake Bed

ATLAS

SAFETY-TYPE TRANSFERS

- *SAFE — because one lever controls forward-reverse-stop.*
- *SAFE — because car stops when operator releases lever.*

Atlas transfer equipment is designed for your specific load and production needs. Optional power includes Storage Battery (Walk-Along or Rider-Type) • Gas-Electric • Diesel-Electric • Cable Reel AC • Cable Reel DC • Cable Reel AC With Fluid Coupling • also remotely controlled cars without trailing cable.

Write today for Bulletin 1283

ATLAS CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

ENGINEERS AND MANUFACTURERS SINCE 1896

WILL SHE LIVE TO GROW UP?

This child has leukemia—one of the most tragic forms of cancer. Only research is keeping her alive.

Ten years ago, children stricken with leukemia—cancer of the blood-forming tissues—had only a few weeks or a few months of life. Today, many of these children have had wonderful, precious months, even years, added to their lives, thanks to dramatic discoveries in the research laboratories.

Until science finds the means to *save* them, however, they live on borrowed time. The American Cancer Society's research program includes $1,500,000 annually for research related to leukemia. Millions of dollars more are needed to conquer this grim disease—a disease which kills 2,000 children each year, and which is taking an increasingly larger toll of the lives of adult men and women.

You can help research find the answers that will save these lives. Give generously to help support the American Cancer Society's intensive research assault against leukemia and all other forms of cancer.

AMERICAN CANCER SOCIETY

PV
PLANET VERSATILITY...

RUNOUT SYSTEM *CONTROLS 40,000-POUND PACKS INDIVIDUALLY*

Planet Corporation's 40,000-pound pack runout system, installed in a large strip mill, is built in 16 individually powered and controlled sections . . . a feature which eliminates damage to edges or corners of the sheets. The runout system starts on the pilers — two prime and one reject. One section is mounted on the platen of each. Four sections extend from each prime piler, three for storage and one for weighing. The reject piler system is the same except it has an extra section which enables the operator to run selected packs off the other side of the piler. The system can handle 40,000-pound prime packs with maximum dimensions of 200″ x 60″ x 54″.

This 40,000-pound pack runout system is more evidence of Planet's versatility . . . its ability to create and build the heaviest of material handling equipment. And like most of Planet engineered equipment, this system is designed to give the producer a better finished product as well as savings in time and labor.

PLAN WITH PLANET If you have a production, materials handling, or automation problem, let Planet demonstrate how its versatile engineering skill, and production and erection know-how can help you. Because of PV, it has paid many leading industrial concerns to "Plan with Planet" . . . it will pay you too. Write or phone today!

PLANET CORPORATION

• ENGINEERED HANDLING SYSTEMS
• AUTOMATION EQUIPMENT
• MILL & FOUNDRY HANDLING EQUIPMENT

1816 SUNSET AVENUE
LANSING, MICHIGAN

96

PALLET ATTACHMENT

△ A new magnetic tin-plate attachment designed for holding loose sheets of tin plate during transporting on a pallet has been announced by The Elwell-Parker Electric Co.

The magnetic action of the attachment securely grips the load to prevent slipping or tipping of the plate.

The magnetic control switch mounted on the truck cowl has a maintained contact position to energize the magnet for securing the load. The "off" position of the switch de-energizes the magnet for releasing the load and for standard fork truck operations.

The truck may be used for other pallet handling operations. Of particular importance, the attachment does not reduce the capacity of the truck and is readily removable for installation of longer forks.

SPEED REDUCERS

△ A new universal worm gear speed reducer that can be mounted in three different positions has been introduced by Link-Belt Co. The units are the newest additions to the company's complete line of worm gear speed reducers.

The units are available in 2½, 3, 3½ and 4-in. centers with up to 13½ hp input rating and 7240 lb-in. output torque rating.

These extremely versatile units have three choices of mountings: worm shaft below gear, worm shaft above gear and output shaft vertical.

Cost of horsepower has been reduced by using a one-piece cast iron housing with external fins for cooling and an aluminum radial fan which directs air over the fins.

BAR SHEAR

△ A new low-knife cropping shear for bar and merchant mill operation has been introduced by Curry Air Shear Corp.

Available in a variety of sizes, this new type shear will cut hot steel rounds up to 1½ in. in diam. Extremely compact in size and weight, it operates from available plant air supply.

The shear cuts automatically whenever material is placed in the jaws, actuating a trip action mechanism. Throat of the knives is

NEW MODEL SHEET & COIL PRINTER

"CHAMPION OF THE LIGHTWEIGHTS"

The advantages of a lightweight sheet and coil printer with all the qualities of Matthews Standard series of mill printers has led to the development of this tested, accepted unit. Check these advantages:

Lightweight

All aluminum printing drum and light weight frame rides lightly and smoothly over the sheet.

Positive action

Wide contact semi-pneumatic drive tires provide positive, non-slip contact and printing action. Gentle, but sturdy.

Uniform ink transfer

A metal transfer roll delivers a uniform film of ink from the fountain to the printing die. Prevents undo wear of the fountain roller and die . . . and saves ink, too.

This unit may have advantages for you. Write today for further details.

JAS. H. MATTHEWS & CO.
3958 Forbes Ave., Pittsburgh 13, Pa.
OFFICES IN PRINCIPAL CITIES

12 in. above ground. The unit requires a floor space of only 18 x 34 in. Over-all height is 30 in.

Shears of this type require no foundation, and require practically no maintenance over long periods of operation. Air pressure should be maintained between 80 and 100 psi.

TEFLON-COATED CUPS

△ The development of Teflon-coated cups for use in hydraulic and pneumatic equipment has been announced by The Garlock Packing Co. This advance in cup design, now being marketed by Garlock, will substantially improve operation of equipment using this type of packing.

Teflon-coated cups reduce the breakaway torque required to operate cylinders; reduce running friction; will not stick to cylinder walls even after prolonged periods of idleness; and eliminate packing chatter and squealing. These advantages extend packing life considerably and greatly reduce downtime.

Teflon, with its low coefficient of friction and anti-adhesive characteristics, has for many years resisted efforts to use it as a coating. Garlock has perfected a technique which overcomes Teflon anti-sticking qualities. A thin layer of Teflon coats and cups and this coating becomes an integral part of the packing. Cost of the new cups is low, only slightly more than ordinary cups.

SCRUBBER-FAN UNIT

△ A new package unit, including scrubber, transition and fan has been fabricated by Robinson Ventilating Co. for handling sulphuric, hydrochloric and low concentrate nitric acid fumes in continuous or batch pickling systems.

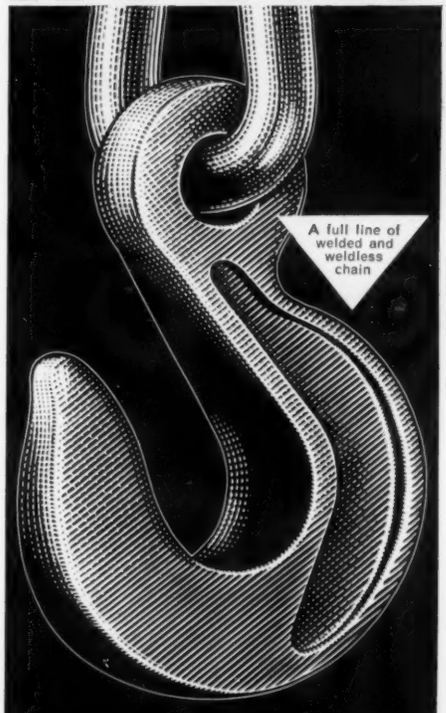
All parts of the scrubber and fan exposed to the air stream are lined with ⅛ in. neoprene. Scrubber is composed of extruded polyvinyl chloride impingement baffles. Piping is rigid PVC and spray nozzles are also of PVC for long life service.

The Type J fan, of heavy duty steel construction, is of nonoverloading backward curve design.

The unit can be supplied to accommodate volumes from 5000 to 40,000 cfm, with fan blade sizes ranging from 27 to 49 in.

PATENTED

TAYCO HOOKS



another advantage of

TM *factory-made*

alloy sling chains!

Pat. No. 2646306

Patented Tayco Hooks are the strongest on the market, for they are drop-forged from special alloy steel with exclusive I-Beam design! Uniform heat-treating, stress-free links, Taylor's quality control and Test Certificate on assembled sling are additional advantages of TM factory-made Alloy Slings. Call your distributor or send for Bulletin 13.

S. G. TAYLOR CHAIN CO., INC.
Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

TM Taylor Made CHAIN SINCE 1873

The unit also features a drain pipe, to drain off contaminants.

MODIFIED SHOVEL

△ A standard, "package" modification for Yale Y-18 industrial tractor shovels to fit them for the special duty requirements of the metals industry and the operating characteristics peculiar to applications around furnaces has been developed by Yale Materials Handling Division, The Yale & Towne Manufacturing Co.

Adaptations made to the standard tractor shovel contribute to over-all efficiency of operation under the duty cycles common in metals work and to the safety and comfort of operators and persons working in the area.

A Protecto-Seal gas tank cap protects the fuel supply in gasoline powered models of the metals industry handling tractor shovel. LP-gas powered models use a 33½-lb ICC container for their fuel.

Laminated tires are standard equipment on the "steel mill" tractor shovel to prevent down-time from tires cut by sharp metal scrap.

The operator is protected by an angular Plexi-Glas shield mounted on the tractor shovel cowl.

Other safety devices include a safety alarm system of buzzer and flashing light when the shift lever is placed in reverse, directional lights and a combination stop-tail light arrangement in place of rear operating lights.

MULTI-LINE PRINTER

△ The Pannier multi-line offset printer was primarily designed to print specification identification, as required by government specifications, on stainless, titanium and aircraft quality steel. Mills using this unit have also found it efficient and practical for printing wide coils, prior to the slitting operation, thereby obtaining numerous printed strips as narrow as ½ in. The unit is also being used profitably on sheets of gasket material and other materials where all-over identification or trade mark printing is desired.

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"Motors and Generators" MG 1-1959, revised, has been published by the National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y. The book contains approxi-

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(*Continued from page 210*)

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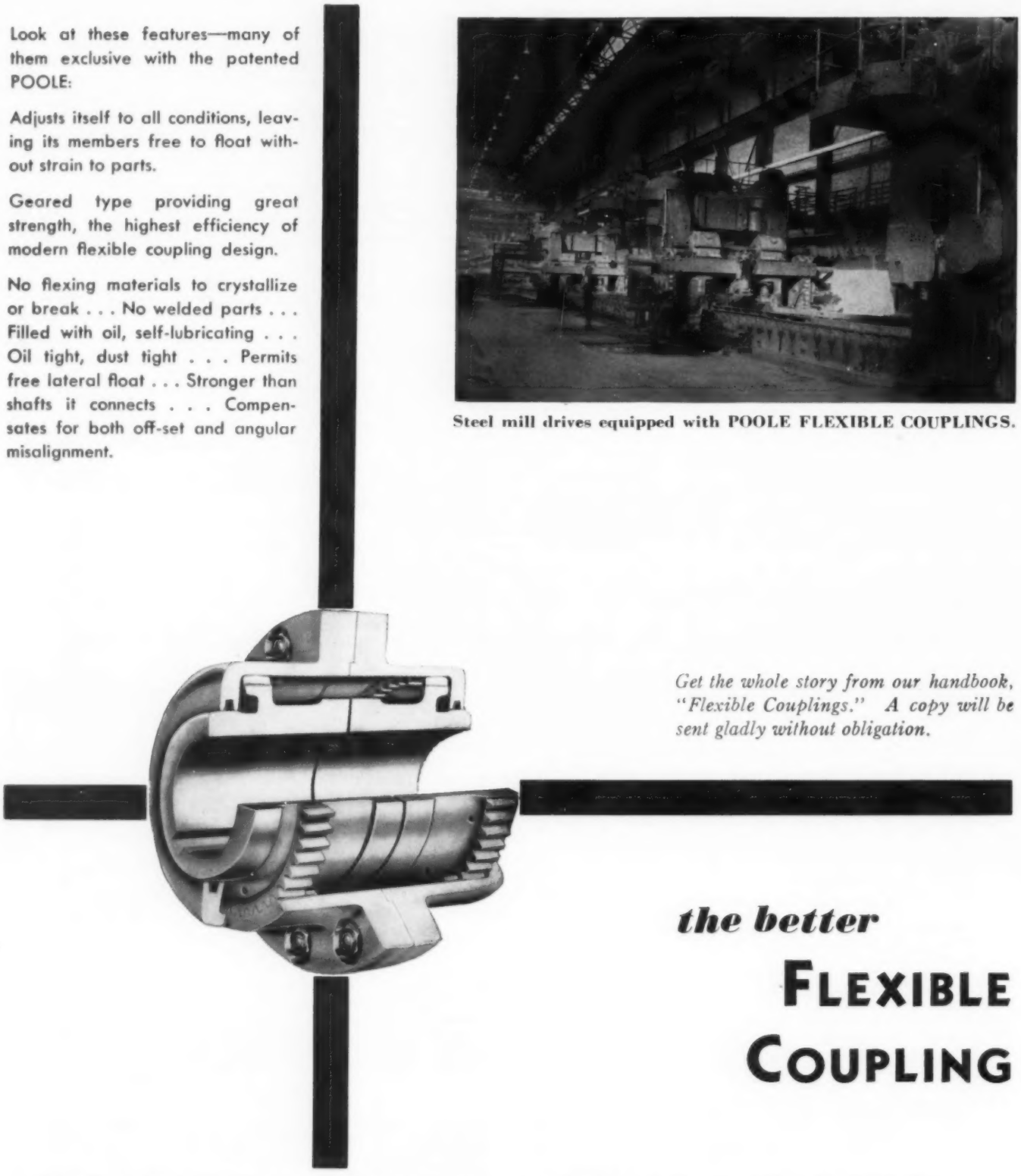

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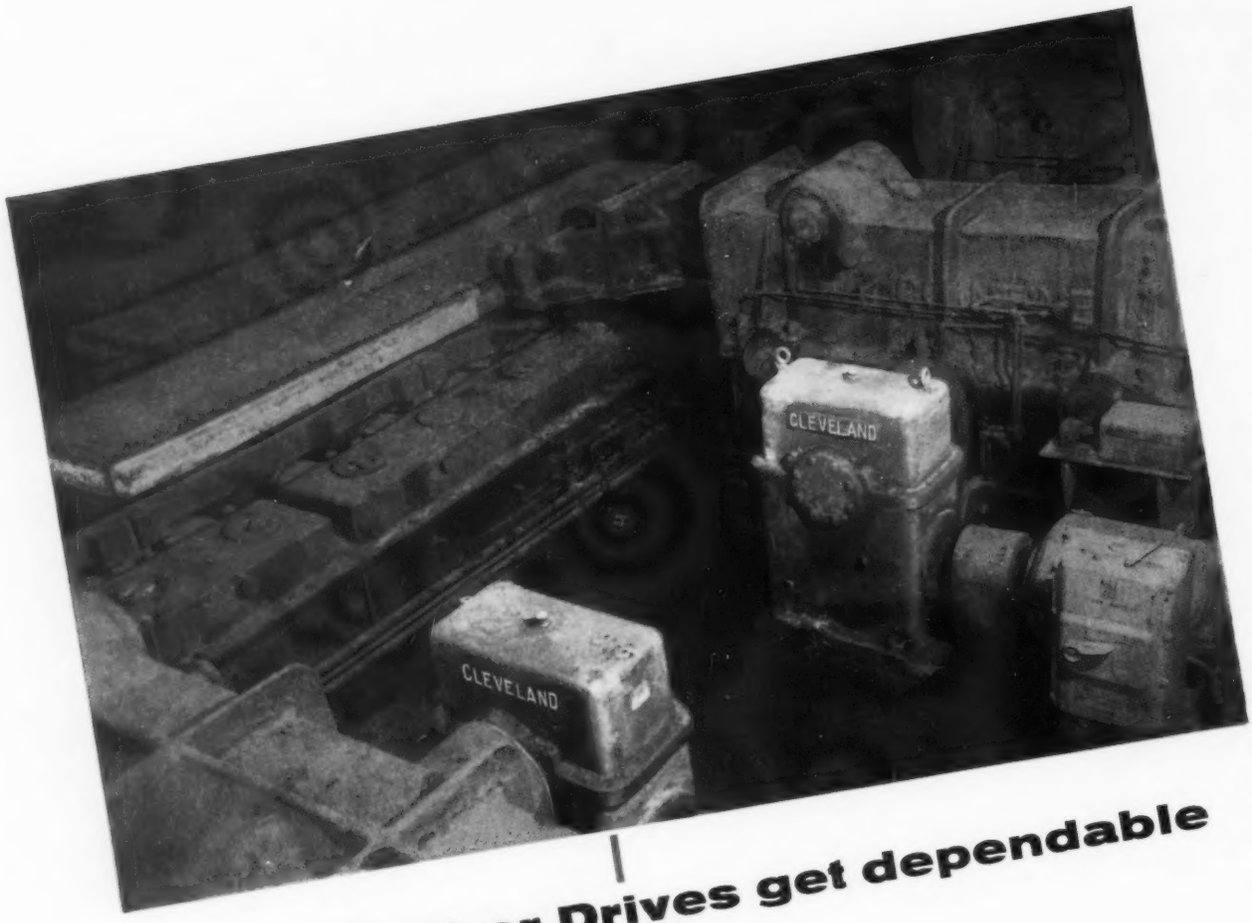

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